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A Digital Simulation Model of Message Handling in the Tactical Operations System: II. Extensions of the Model for Interactivity with Subjects and Experimenters

by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Extensions and improvements are described to a previously developed digital computer model for simulating the actions of operational field army personnel performing their message processing tasks during a Tactical Operations Systems (TOS) mission. The computer model was made interactive via cathode ray tube to: (1) enable an experimenter to initiate and control computer simulation runs, and (2) allow TOS operators at a computer terminal to perform selected tasks during the simulation. A series of model improvements found desirable, as a result of prior simulation run experience, is described.

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19. Procedures
Operator
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Methodologies, system evaluation
Sensitivity tests
Model validation
Digital simulation model

20. A revised version of the "user's manual" for the model is presented along with an Interactive Model User's Manual.

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CHAPTER I

INTRODUCTION

In June 1972, a report was published (Siegel, Wolf, & Leahy, 1972) which describes a new digital computer model for simulation of message processing tasks performed by field army personnel during a Tactical Operations System (TOS) mission. That report defined variables, described a computational logic flow which integrated the variables into a coherent digital simulation model, and presented the results of initial tests of model sensitivity.

As a result of model utilization and testing, a number of avenues for model improvement became evident. These may be grouped into the following three general categories:

1. extension to allow an experimenter, seated at a CRT display terminal, to initiate, control, and monitor results from simulation runs

2. extension to allow one or more subjects, seated at CRT display terminals, to participate in the simulated TOS exercise, by performing specific TOS tasks, selected as not best allocable to digital simulation, while the model simulates the balance of the tasks

3. strengthening of the model by incorporating changes such as an improved system responsiveness calculation scheme, an improved stress function, and an extension of the shift limit capacity

The current report has as its purpose the description of the implementation of the three sets of features into the previously developed model. To achieve the desired result, the computer program (Siegel, Wolf, & Leahy, 1972) representing the model was modified and, as a result of changes described herein, two new computer programs were developed.

The first is a program which is a revision of the basic model containing improvements only and does not contain interactive features. This is termed the "Strengthened Model." The second is an extended model which incorporates the changes required for the interactive features including both the experimenter and subject interaction, as well as the model improvements

included in the "strengthened model" (with the exception of shift extensions, which are impractical for interactive runs). This is called the "Interactive Model."

The remainder of this chapter presents an overview of the original model in preparation for the more detailed description of the three major feature changes which are presented in Chapters II, III, and IV respectively. The reader who is already familiar with the general functional capabilities of the basic model may wish to turn directly to Chapter II.

The TOS Computer Simulation

The TOS simulation model combines the effects of such features as message queuing, detailed message processing procedure, error rates, and personnel characteristics, along with stochastic variations to yield predictions of system performance. Parameters which may be varied to study their impact on system performance include:

- hours per shift
- number of action officers
- number of IOD operators
- operator fatigue
- error rates (per hour, per type of error, per type of message)
- personnel characters (4 variables)
- message arrival frequency
- message workload
- message type mix
- message length
- message handling procedure

Specifically, on the basis of input data, the model generates message workload for the first hour of a shift for the simulated TOS personnel. It assigns priorities and other characteristics to the simulated message and forms a message queue. Then, the simulation of the processing of these messages by the AO and IOD personnel takes place to yield the hourly output record, as described below. When the simulation is completed for the first hour of the shift, a message workload is generated for the second hour. Messages which were carried over from the first hour are added to this second hour workload, and the simulation of the processing for the second hour of the shift takes place. An hourly summary for

the second hour is then produced. This procedure continues until the total shift has been simulated, at which point a summary for the shift is produced.

Due to the stochastic nature of many of the simulation aspects, a number of repetitions is required to produce a stable result. Repetitions of a simulation with the same set of input variable conditions is called a run. At the conclusion of a run, the run summary (integrating results of various repetitions) is produced.

The program allows for detailed message processing description, hourly summary, shift summary, and run summary output options. The detailed message processing output shows the fine grain of the results of the simulation of action officer's selection and formating, followed by IOD processing of the messages which arrive each hour of a shift.

The hourly summary presents a consolidation of the results of a simulated hour's work and includes items such as: number of messages completed, number of messages rejected, number of messages unprocessed, time spent working, end of hour stress level, end of hour level of aspiration, time spent performing various processes, average time per message, errors, and information loss.

The shift summary, produced at the conclusion of one n hour shift, provides a consolidation of certain information derived at the end of each hour, e. g., total messages processed, time worked, overall effectiveness, errors.

The simulation run summary, produced after N simulations of the same shift, consists of five parts--manpower utilization, message processing times, overall effectiveness indicator, workload summary, and error summary. The manpower utilization summary shows the mean time each man worked for each of the simulated hours, the mean amount of time each man spent on a message by each hour, and the final stress and aspiration levels of each man. The message processing time summary shows by message type, priority, and hour the amount of time spent in each of five time segments. The effectiveness components--thoroughness, completeness, responsiveness and accuracy, as well as overall effectiveness--are also shown for each simulated hour. The run workload summary contains the mean number of arriving messages which were completed or carried over during each simulated hour, as well as the number of rejected or interrupted messages.

The error summary shows the mean number of errors of various types (i. e., omission, abbreviation/ typographic/ spacing, or commision) for each hour and for each message type.

The end result is the ability to answer questions such as:

1. How does system effectiveness vary as a function of message load?
2. How does system effectiveness vary as a function of message arrival time distribution?
3. How does system effectiveness vary as a function of personnel proficiency?
4. What is the effect of increasing or decreasing the manning level or personnel proficiency?
5. How much stress was on the operators during the performance of the work of each hour?
6. How does system effectiveness vary as a function of operator level of aspiration?
7. What is the error rate for various message types and for various mannings and personnel attributes within manning?
8. How much time was spent, on the average, processing each type of message?
9. How much time was spent, on the average, for each type of message in performing acts such as: message screen, message transform, transformed message input?
10. How many error returns were involved for each type of message?
11. What is the success rate?
12. How effective was the work in terms of the following four criteria: accuracy, thoroughness, responsiveness, and completeness?

CHAPTER II

THE STRENGTHENED MODEL

Introduction

Six enhancements to the basic model were developed and tested as a part of the current work. These are itemized below and described in subsequent sections of this chapter:

1. revision of the responsiveness formula in the system effectiveness calculation and a correction of the formula for calculating the systems effectiveness index

2. addition of the capability to generate more than one TOS message from a single input message

3. correction of the calculation for the number of undetected errors

4. incorporation of the effects of message priority on operator stress

5. extension of the existing limit from one shift of up to 12 hours to as long as 24 hours (including up to four shifts)

6. improvement in the content and format of the printed output

Appendix A to this report presents a revised user's manual for the Strengthened Model including: principal subscripts, card types and function, card layouts, a glossary of variables, and subroutine names and functions. The revised model flow logic is presented in Appendix C for the Interactive Model (i. e., including the Strengthened Model).

Responsiveness

A numerical value for the total system effectiveness is calculated after each hour of simulated operation. Within the simulation, effectiveness is a function of four factors: responsiveness, completeness, thoroughness, and accuracy. A reexamination of the results of prior runs indicated that the responsiveness component yielded unreasonably small values when compared on a corresponding scale with the others.

In a reevaluation of this function, it was determined that this important measure should properly be calculated on the basis of two independent factors. First, there is the basic operator responsiveness which should measure the speed with which the assigned operators are able to process an average incoming message, once they have begun to work on it. Second, there is the equally important system criteria which should measure the queue waiting time of messages prior to operator processing.

To accomplish this conjoint consideration, two new variables, average handling time (AHT) and average queue time (AQT), were introduced. These are calculated at the end of each mission hour as means over all operators for the hour. From these data, two multiplicative factors, Y1 and Y2, are calculated, as shown in Figure 2-1. The resultant responsiveness measure [EC(3)] is then calculated as $EC(3) = Y1 \cdot Y2$ and is limited to the range zero to one.

The functions in Figure 2-1 were developed so that:

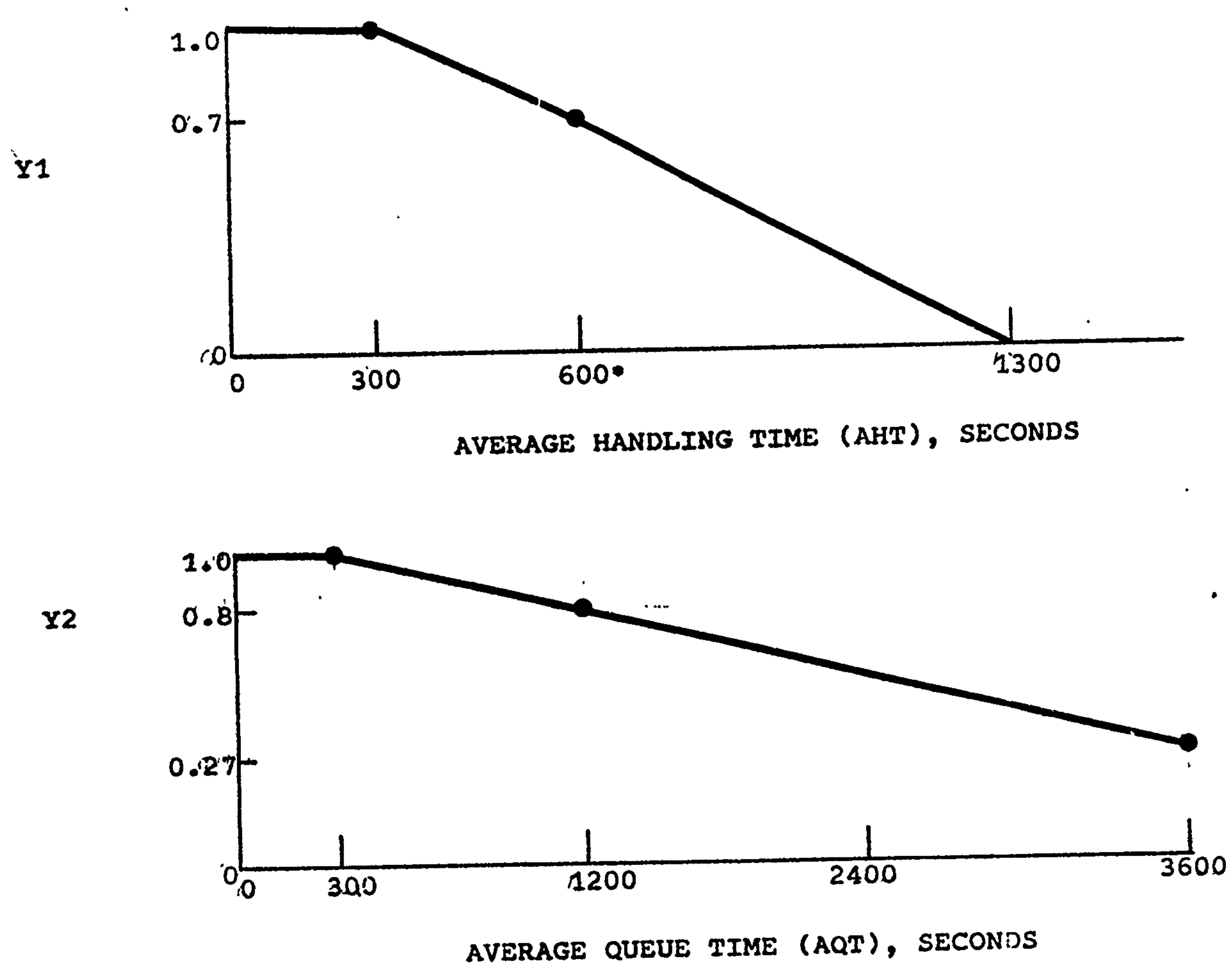
1. the first factor will have a value of one (perfect score) as long as the AHT is less than half of the TOS average message handling time of 600 seconds

2. Y1 will have a value of 0.7 when the results for the hour equal the TOS average of 600 seconds

3. Y2 will have a value of one (no degradation of Y1 score) when the average message is in the queue for five minutes or less

4. Y2 will have a value of 0.8 when the average message is in the queue for 20 minutes

5. linear relationships hold for other values



* 600 SECONDS IS
THE AVERAGE TOS OPERATOR PROCESSING TIME PER MESSAGE

Figure 2-1. Functional relationships, revised responsiveness calculation.

Thus:

$$Y1 = 1 \qquad \text{if } AHT \le 300$$
$$Y1 = 1.3 - 0.001(AHT) \qquad \text{if } AHT > 300$$
$$0 \le Y1 \le 1$$

and

$$Y2 = 1 \qquad \text{if } AQT \le 300$$
$$Y2 = 1.0666 - 0.000222 \qquad \text{if } AQT > 300$$
$$0 \le Y2 \le 1$$

Results from this implementation have yielded more reasonable responsiveness [EC(3)] and system effectiveness values.

Correction of Effectiveness Formula

The formula for the effectiveness calculation which combines four factors--accuracy, thoroughness, responsiveness, and completeness--was presented and its characteristics described previously (Siegel, Wolf, & Leahy, 1972). However, the calculation was incorporated into the model erroneously. The correct FORTRAN representation follows:

$$EFF = \left[\frac{(CC12)^2 + (CC13)^2 + (CC14)^2 + (CC23)^2 + (CC24)^2 + (CC34)^2}{6}\right] \bullet$$

$$[W(1)EC(1) + W(2)EC(2) + W(3)EC(3) + W(4)EC(4)]$$

$$+ \left[\frac{6 - (CC12)^2 + (CC13)^2 + (CC14)^2 + (CC23)^2 + (CC24)^2 \; (CC34)^2}{6}\right] \bullet$$

$$[EC(1)^{W(1)}][EC(Z)^{W(2)}][EC(3)^{W(3)}][EC(4)^{W(4)}]$$

where:

EFF	=	effectiveness
CC12	=	correlation between thoroughness and completeness
CC13	=	correlation between thoroughness and responsiveness
CC14	=	correlation between thoroughness and accuracy
CC23	=	correlation between completeness and responsiveness
CC24	=	correlation between completeness and accuracy
CC34	=	correlation between responsiveness and accuracy
W(IC)	=	weight for each component
EC(1)	=	thoroughness
EC(2)	=	completeness
EC(3)	=	responsiveness
EC(4)	=	accuracy

Multiple Input Messages

In the field, it is not uncommon that a message entering the system for automation will in fact generate more than one TOS input stimulus message, each of which must be processed by the operational personnel on duty. Incorporation of this feature would not only yield improved realism, but would allow the system analyst to determine the effect of the ratio (number of generated to input messages) on system performance efficiency.

To accomplish this enhancement, a new item was added to the model input data, RMPS(IT), which specifies the average number of TOS messages entered into the TOS system as a result of input stimulus messages of each type. The program was modified to accept these inputs and to calculate, for each input stimulus message, a value from a Poisson distribution to represent the actual number of TOS messages to be processed as a result of the single input stimulus of type IT: RP(RMPS(IT). The message generation subroutine was then adjusted to generate that integral number of messages for processing. Each resulting message is assigned the same time of arrival, as calculated by MESGEN, although the other message characteristics (priority, type, length) are calculated independently.

Undetected Errors

Previously, the number of undetected errors was calculated as a Poisson distributed variable as a function of the operator rates provided as input, and of the message length. A review of this function resulted in the conclusion that operator accuracy, included in the model as the precision variable, PREC(M), should also be incorporated into the undetected error calculation. Since precision is scaled from 1.2 (highly inaccurate operator) to 0.8 (highly accurate operator), the precision factor was made a multiplicative factor, and the resulting calculation became:

$$\mathrm{TNUE} = \sum_{\mathrm{IT}} \mathrm{RP}\left[\mathrm{ER(IE,\ IT)}\ \frac{\mathrm{LENGTH\ (IK)}}{100}\right]\mathrm{PREC(M)}$$

where:

TNUE	=	total number of undetected errors
RP	=	Poisson distributed variable
ER	=	error rate
LENGTH	=	no. of characters in the message
PREC(M)	=	operator precision

Revised Stress Calculation

Previously, the stress of an operator performing a TOS mission was determined as a function of the number of nonroutine messages in the queue (inbasket), the number of available crew members to process messages, and the operator stress threshold values provided as input parameters. It was decided that the logic of this calculation would be improved if all five levels of message priority were also considered. Accordingly, the logic was modified to allow message priority, as well as number of available operators and number of messages in the queue to affect operator stress. In the modification, routine messages exert no additional stress effect, while messages of the other four priority categories influence stress. Specifically, messages having higher priorities count as more than one message in the queue, as shown in the Table 2-1.

Table 2-1

Assigned Message Equivalents for Each Type of Priority

Priority	Type of Priority	Number of Equivalent Messages ISTKNT(IP)	Comment
1	routine	0	no change
2	priority	1	no change
3	operational immediate	2	increased importance
4	flash	5	increased importance
5	presidential interrupt	10	increased importance

The effect of this change is to generate a higher operator stress condition in the cases in which higher priority messages are in the queue.

Extension of the Simulation Limit

As originally designed, the model was capable of simulating operator shifts of up to 12 hours. Thus, the original model handled crew (shift) changes only by multiple runs. However, since the TOS mission is actually executed in shifts, a logical extension to the model was the incorporation of the capability to simulate a full 24 hour day including several shift changes.

This extension of capability represents a major logical change to the program as it involves program changes to allow reading of new operator parameter data (to simulate the changing of personnel) at the end of each work shift, along with required storage of simulation results for each shift and a summarization at the completion.

To incorporate this multishift concept, two new items of data were added to the mission input, the number of the shift being simulated (ICHAIN) and the time at beginning of the shift (TZERO). The input NSHIFT (number of iterations per shift) remains unchanged.

The computer program was modified to accomplish the logic as shown in flow chart 1. These additions occur after the subroutine ITSUM following circle f in the Appendix C flow charts. The modifications accomplished the following:

1. after subroutine ITSUM summarizes results of one shift of IHMAX hours, the remaining message queue is saved to be used as the backlog queue of the corresponding iteration of the next shift

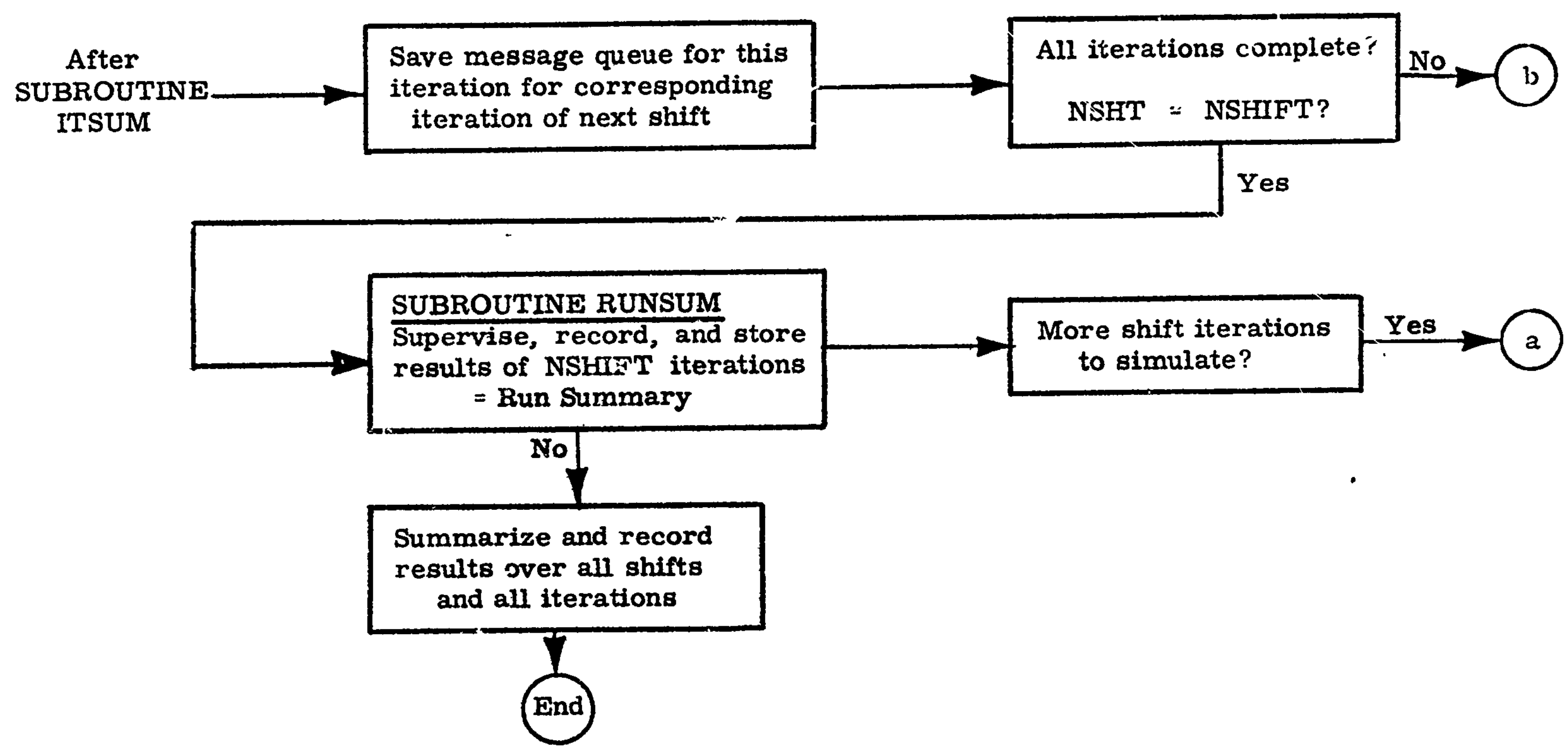
2. simulations of IHMAX hour shifts are continued and summarized until all NSHIFT iterations are completed

3. then subroutine RUNSUM summarizes the results of iterations of that shift in a Run Summary

4. the process repeats for all additional required shifts

5. when all required shifts have been simulated (NSHIFT iterations each), a final summary is calculated and printed

Revised output tabulation forms result from these changes. For reference purposes, a complete set of sample output tabulation formats is itemized in Table 2-2 and presented in Figures 2-2 through 2-9a.



Flow Chart 1. Additional logic to incorporate the multishift capability.

PAGE 1

RUN 6- 6/5/73 APS

NO. OF SHIFT ITERATIONS	10	NO. OF SIMULATED DAY	1
NO. OF HOURS PER SHIFT	4	INITIAL BACKLOG #G3	0
NO. OF ACTION OFFICERS	4	RANDOM NUMBER	11531571
NO. OF IOU OPERATORS	3		

PROBABILITY OF UNDETECTED ERROR IN CCC
LOW IMPORTANCE .051
SIGNIFICANT .013

SYSTEM RESPONSE TIME TO INQUIRY
MEAN 0
SD 0

OPERATOR PARAMETERS

MAN	SPEED	PRECISION	STRESS THRESHOLD	ASPIRATION
AO-1	1.15	1.00	10.00	.900
AO-2	1.15	1.00	10.00	.900
-G3-	1.15	1.00	10.00	.900
IOU1	1.15	1.00	10.00	.900
IOU2	1.15	1.00	10.00	.900
IOU3	1.15	1.00	10.00	.900

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MESSAGES PER STIMULUS BY TYPE

1	2	3	4	5	6	7
0	0	0	0	0	0	4

HOUR PARAMETERS

CUMULATIVE MESSAGE FREQUENCY BY TYPE / CUM. MSG FREQ. BY PRIORITY

HOUR	1	2	3	4	5	6	7	8	1	2	3	4	5
1	.17	.42	.50	.84	.98	.99	1.00		.70	.90	1.00	1.00	1.00
2	.17	.42	.50	.84	.98	.99	1.00		.70	.90	1.00	1.00	1.00
3	.17	.42	.50	.84	.98	.99	1.00		.70	.90	1.00	1.00	1.00
4	.17	.42	.50	.84	.98	.99	1.00		.70	.90	1.00	1.00	1.00

-------INPUT MESSAGES FROM OUTSIDE-------

HOUR	DELIVERIES PER HOUR ROUTINE	DELIVERIES PER HOUR NOT-ROUTINE	NUMBER OF MESSAGES LAST 1/4 HR	NUMBER OF MESSAGES ANYTIME
1	3.0	11.0	2	8
2	3.0	11.0	2	8
3	3.0	11.0	3	12
4	3.0	11.0	2	3

ERROR FREQUENCY

TYPE	MESSAGE TYPE 1	2	3	4	5	6	7	ERROR RETURNS E	G3	IOU
1	9.30	7.10	2.00	2.00	4.60	2.10	14.20		.120	.013
2	5.80	4.50	1.30	1.30	3.00	1.30	9.10		.120	.013
3	9.30	7.10	2.00	2.00	4.60	2.10	14.20		.120	.013
4	0	0	0	0	0	0	0		0	0

EFFECTIVENESS COMPONENTS

CORRELATIONS BETWEEN COMPONENTS
CC12= .500
CC13= .500
CC14= .500
CC23= .500
CC24= .500
CC34= .500

NO. OF CHARACTERS

	MESSAGE TYPE 1	2	3	4	5	6	7	8
IN COMPUTER (M)	272.00	236.00	72.00	300.00	74.00	100.00	148.00	
IN COMPUTER (SD)	176.00	153.00	47.00	195.00	48.00	65.00	96.00	

WEIGHTS OF EACH COMPONENT
W(1)= .250
W(2)= .250
W(3)= .250
W(4)= .250

Figure 2-2. Sample input data printout.

TASK ANALYTIC DATA

TASK	ELEMENT	TYPE	CRITICAL	SEGMENT	NEXT-FAIL	NEXT-SUCC	MEAN-TIME	SIGMA	PROBABILITY	UNDETECTED-ERROR TYPE	UNDETECTED-ERROR PROB
1											
	1	1			2	2	8.00	2.00	.990		0
	2				2	3	5.00	1.50	.990		0
	3				3	4	20.00	3.00	.800		0
	4		C	3	4	5	15.00	4.00	.990		0
	5				5	6	12.00	2.50	.900		0
	6				6	7	12.00	2.50	.900		0
	7	2			8	8	.50	.01	1.000	T	.17
	8		C		9	9	10.00	2.00	.660		0
	9				8	10	15.00	2.70	.800		0
	10		C	4	10	0	20.00	10.00	.990		0
2											
	1		C	3	1	2	15.00	4.00	.990		0
	2				2	3	12.00	2.50	.900		0
	3				3	4	12.00	2.50	.900		0
	4	2			5	5	.50	.01	1.000	T	.17
	5		C		6	6	10.00	2.00	.660		0
	6				5	7	15.00	2.70	.800		0
	7		C	4	7	0	20.00	10.00	.990		0
3											
	1				1	2	7.00	1.50	.990		0
	2		C	5	2	3	5.00	1.00	.960		0
	3	4			4	4	.30	.02	1.000		0
	4	2			5	5	.40	.01	1.000	.	.01
	5				5	6	12.00	3.00	.700		0
	6		C	6	7	7	4.20	1.20	1.000		0
	7	4			8	8	2.00	.50	1.000		0
	8	6			9	13	2.00	.50	1.000		0
	9	3			4	10	.70	.01	.950		0
	10				10	11	15.00	.50	.900		0
	11		C		11	12	5.00	1.00	.900		0
	12				12	6	5.00	1.00	.990		0
	13	3		7	14	0	0	0	.100		0
	14	4			15	15	35.00	10.00	1.000		0
	15			7	15	0	10.00	1.20	1.000		0

TASK ANALYSIS ALLOCATION

OPERATOR	MESSAGE TYPE 1	2	3	4	5	6	7	8
1	1	1	1	2	1	1	1	1
2	3	3	3	3	3	3	3	3

Figure 2-3. Sample input task analytic data.

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SIMULATION OF 2-MAN (AO + UIOO) MESSAGE PROCESSING CHAIN 2

MESSAGES GENERATED OR CARRIED OVER FOR HOUR 1 FOR G3

ORDER	ARRIVED (SEC)	PRIORITY	TYPE	LENGTH	OUTCOME	TOTAL UNDET ERR	ERROR RETURNS	INTERUPTED MAN	INTERUPTED ELEMENT	CUMULATIVE MSG NO/
1	6320.0	1	1	50		0	3		0	1
2	6320.0	1	1	57		0	0		0	2
3	6320.0	1	1	51		0	0		0	3
4	6788.9	2	2	47		0	0		0	8
5	6786.9	1	1	90		0	0		0	7
6	6788.9	1	1	106		0	0		0	9
7	6788.9	1	1	87		0	0		0	10
8	6788.9	1	1	61		0	0		0	11
9	6825.0	1	2	54		0	0		0	5
10	6825.0	1	1	40		0	0		0	4
11	6963.5	1	1	109		0	0		0	12
12	6963.5	1	1	93		0	0		0	13
13	6963.5	1	1	47		0	0		0	14
14	6963.5	1	1	45		0	0		0	15

Figure 2-4. Sample model generated message backlog data.

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SIMULATION OF 2-MAN (AO + IOOD) MESSAGE PROCESSING                          PAGE   51

MESSAGE NUMBER      3          MAN               IOO1          DAY          1
MESSAGE TYPE      AUD          STRESS FACTOR     1.00          HOUR         1
MESSAGE ORDER       3          FATIGUE           1.90          ITERATION    2
                               ASPIRATION        1.00
                               CUM. IDLE       365.18
MESSAGE ARRIVAL     715.6
MESSAGE START       738.5

ELEMENT  EXECUTION CUMULATIVE OUTCOME  TYPE OF  CRITIC  SEGMENT  ERROR   ERROR
  NO.      TIME       TIME     (SFR)   ELEMENT  -ALITY   ENDED   TYPE   RETURNS

   1        8.81     747.33     S        0                 5               5
   2        3.11     750.44     S        0        C        6               5
   3         .30     750.75     S        4                 0               5
   4       54.52     805.27     S        2        C        0               5
   5        6.28     811.55     F        0                 0               5
   5       11.89     823.44     S        0                 0               5
   6        4.19     827.63     S        0        C        7               5

 MESSAGE   3
 COMPLETED BY IOO1
 TRANSFORM ERRORS
  COMMISSION          0
  ACHEV/TYPO/SPAC     0
  OMISSION            0
 OTHER ERRORS         0

 TOT. UNDET.  ERRORS  0

 NO. ERROR RETURNS    5
 INFORMATION LOSS     0

     MESSAGE NO.   3
SEGMENT  1      2       3       4       5       6       7
              572.7   580.7   715.6   747.3   750.4   827.6
```

Figure 3-5. Sample detailed message processing output.

END OF HOUR RESULTS HOUR 1
DAY 1
ITERATION 2

OPERATOR PERFORMANCE DATA

MAN	MESSAGES: COMPLETED	MESSAGES: REJECTED	MESSAGES: INTERRUPTED	TIME: WORKED	TIME: OTHER	FINAL: STRESS	FINAL: ASPIRATION	FINAL: PERFORM
1	13	0	0	3289.7	310.3	0	.91	.88
2	0	0	0	0	3600.0	0	.90	.90
3	12	0	1	1929.8	1670.2	0	.94	1.00

MESSAGE PERFORMANCE DATA

AVERAGE TIME PER MESSAGE	1151.5
MESSAGES IN AO-G3 QUEUE AT HOUR START	23
TOTAL INFORMATION LOSS	0
EFFECTIVENESS COMPONENTS	
THOROUGHNESS	.96
COMPLETENESS	.93
RESPONSIVENESS	.81
ACCURACY	1.00
EFFECTIVENESS=	.60

DETAILED MESSAGE TIMING

CUMULATIVE MESSAGE NUMBER	TYPE	T1	T2	T	T4	T5
1	1	1303.2	6.5	198.8	5.4	3.8
2	1	360.8	18.9	193.0	5.9	5.0
3	1	572.7	16.0	126	31.7	3.1
4	1	715.6	10.5	225.1	7.3	5.2
5	1	951.2	13.6	83.4	5.3	5.4
6	2	1048.2	17.0	238.0	6.8	6.6
7	1	0	11.6	349.2	8.4	4.8
8	1	1508.5	11.1	333.6	7.5	2.9
9	1	1853.1	17.6	370.1	5.7	6.2
10	1	2240.8	23.5	313.2	6.3	7.5
12	1	92.0	13.4	244.5	8.0	7.2
13	1	0	14.6	149.0	6.0	4.8

MESSAGE TYPE	NUMBER COMPLETED	T1	T2	T3	T4	T5
1	11	872.5	14.3	235.2	9.4	5.1
2	1	1048.2	17.0	238.0	6.8	6.6
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Figure 2-6. Sample end of hour simulation summary.

SIMULATION OF 2-MAN (AO + UIOD) MESSAGE PROCESSING PAGE 81

RESULTS OF SHIFT ITERATION 2

HOUR	THOROUGHNESS	COMPLETENESS	RESPONSIVENESS	ACCURACY	EFFECTIVENESS
1	.96	.93	.81	1.00	.60
2	.56	.92	.96	1.00	.46

TYPE	N	T1	T2	T3	T4	T5
1	14	729.1	14.5	237.0	8.7	5.4
2	1	1048.2	17.0	238.0	6.8	6.6
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Figure 2-7. Sample end of shift simulation summary.

RUN 6-   6/5/73 APS

SHIFT 1 SUMMARY

MANPOWER UTILIZATION

HOUR	MAN	TIME WORKED	PROP	TIME OTHER	MSG UNITS PROCESSED	MEAN TIME PER MESSAGE	FINAL STRESS	FINAL ASPIRATION
1	1	1592	.44	2008	5	283	.033	.907
	2	1117	.31	2483	3	284	0	.905
	3	42	.01	3558	0	209	.533	.900
	4	1099	.31	2501	2	280	.033	.901
	5	1071	.30	2529	2	395	0	.901
	6	1031	.29	2569	2	429	0	.900
2	1	1407	.39	2193	5	265	.133	.909
	2	1174	.33	2426	4	258	0	.907
	3	38	.01	3562	0	191	.500	.900
	4	1456	.40	2144	4	416	0	.901
	5	1363	.38	2237	3	387	.033	.901
	6	1350	.37	2250	3	374	.033	.900
3	1	2022	.56	1578	7	265	0	.910
	2	1732	.48	1868	6	285	.067	.908
	3	247	.07	3353	0	316	.567	.902
	4	1612	.45	1988	4	342	.033	.901
	5	1744	.49	1851	4	379	.067	.901
	6	1785	.50	1815	4	407	.033	.900
4	1	810	.23	2790	3	[illegible]	.067	.910
	2	578	.16	3022	2	[illegible]	0	.908
	3	58	.02	3542	0	418	.567	.902
	4	656	.18	2944	2	364	0	.901
	5	1004	.28	2596	2	475	0	.901
	6	634	.18	2966	2	351	0	.900
MEANS FOR EACH MAN PER MESSAGE UNIT	1	1458	.40	2142	213	272	.058	.909
	2	1150	.32	2450	168	272	.017	.907
	3	96	.03	3504	13	296	.542	.901
	4	1206	.33	2394	133	355	.017	.901
	5	1297	.36	2303	127	401	.025	.901
	6	1200	.33	2400	121	391	.017	.900
TOTALS		6406	.06	15154	775	1986	.675	5.419
GRAND MEANS		1068	.30	2532	129	331	.112	.903

Figure 2-8. Sample simulation run summary.

RU: 6- 6/5/73 APS-J.P.

TIME SEGMENTS

HOUR	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	TOTAL MESSAGES
1	37	.06	44	.07	222	.36	19	.03	299	.48	621	76
2	51	.07	42	.06	232	.33	39	.06	337	.48	701	117
3	66	.10	48	.07	222	.32	36	.05	319	.46	691	131
4	16	.02	44	.07	240	.36	27	.04	343	.51	670	66
MEAN	47	.07	45	.07	228	.34	32	.05	324	.48	677	390

TYPE MSG	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	61	.06	60	.06	262	.26	43	.04	571	.57	996	67
2	42	.05	60	.08	230	.30	25	.03	410	.53	768	100
3	73	.17	59	.14	136	.32	42	.10	112	.27	421	27
4	38	.06	17	.03	270	.45	27	.04	254	.42	606	135
5	46	.11	59	.14	134	.32	34	.08	146	.35	418	58
7	138	.14	58	.06	159	.16	124	.13	509	.52	987	3

PRIOR MSG	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	60	.09	44	.06	225	.33	31	.05	319	.47	680	276
2	18	.03	49	.07	232	.35	35	.05	333	.50	668	80
3	9	.01	40	.06	239	.36	31	.05	346	.52	666	34

HOUR	COMPONENTS: THOR	COMP	RESP	ACC	EFFECTIVENESS
1	.86	.66	.71	.49	.66
2	.95	.66	.65	.39	.63
3	.89	.65	.67	.41	.63
4	.86	.65	.65	.40	.59
MEAN	.89	.65	.67	.42	.63

Figure 2-8a. Sample simulation run summary continued.

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RUN 6- 5/73 APS

WORKLOAD SUMMARY

HOUR	BACKLOG AO/G3	BACKLOG IOD	MESSAGES DELIVERED LAST 1/4 HR	MESSAGES DELIVERED ANYTIME	COMPLETED AO/G3	COMPLETED IOD	REJECTED AO/G3	REJECTED IOD	INTERRUPTED AO/G3	INTERRUPTED IOD
					MESSAGE UNITS					
1	0	0	2	8	9.5	7.2	0	0	.5	2.0
2	.5	2.3	2	9	10.2	11.6	0	0	.3	.9
3	.3	.9	3	12	14.2	12.8	0	0	1.1	2.0
4	1.1	2.3	2	3	5.5	6.5	0	0	.6	1.3

ERROR SUMMARY - BY HOUR

HOUR	ERROR TYPE 1	ERROR TYPE 2	ERROR TYPE 3	ERROR TYPE 4	ERROR RETURNS	INFORMATION LOSS	NUMBER OF MESSAGES UNITS
1	15.4409	9.2047	15.5556	0	3.5556	4.1764	171
2	10.5000	6.6759	10.3981	0	5.7222	6.4722	216
3	13.8292	8.8645	13.7582	0	5.2747	5.5092	273
4	11.3167	6.6500	10.4333	0	5.9500	6.6167	120

ERROR SUMMARY - BY MESSAGE TYPE

MESSAGE TYPE	ERROR TYPE 1	ERROR TYPE 2	ERROR TYPE 3	ERROR TYPE 4	ERROR RETURNS	INFORMATION LOSS	NUMBER OF MESSAGES UNITS
1	26.5458	16.9353	28.3597	0	10.3309	12.1007	139
2	19.3596	12.0197	17.9310	0	6.9655	8.3448	203
3	1.6364	.9091	1.5273	0	1.8545	.6182	55
4	6.6782	3.9624	6.4436	0	2.6090	2.8797	266
5	3.2613	2.3964	3.6937	0	2.6486	1.6216	111
7	16.3333	11.6667	20.6667	0	9.6667	9.0000	6

Figure 2-8b. Sample simulation run summary continued.

SUMMARY OF SHIFT DATA

MANPOWER UTILIZATION MEANS

SHIFT	TIME WORKED	PROP	TIME OTHER	MESSAGES PROCESSED	MEAN TIME PER MESSAGE	FINAL STRESS	FINAL ASPIRATION
1	1757	.49	1843	31	216	0	.926
2	922	.26	2678	17	212	.167	.914
MEANS	1339	.37	2261	24	214	.083	.920

TIME SEGMENTS

SHIFT	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	823	.75	15	.01	250	.23	10	.01	5	.00	1103	31
2	944	.75	16	.01	120	.10	165	.13	5	.00	1256	25
MEANS	883	.75	15	.01	180	.16	88	.07	5	.00	1180	28

TIME SEGMENTS

SHIFT	TYPE	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	1	809	.74	15	.01	250	.23	11	.01	5	.00	1089	26
1	2	895	.76	17	.01	247	.21	6	.01	6	.01	1172	5
2	1	976	.76	15	.01	103	.08	186	.14	5	.00	1286	22
2	2	864	.73	18	.01	294	.25	9	.01	7	.01	1192	3
MEANS	1	892	.75	15	.01	177	.15	98	.08	5	.00	1188	24
	2	860	.74	18	.01	270	.23	8	.01	7	.01	1182	4

Figure 2-9. Sample simulation shift summary.

SHIFT	PRIOR	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	1	911	.77	15	.01	245	.21	10	.01	5	.00	1186	28
1	2	0	0	16	.05	296	.91	7	.02	6	.02	325	3
2	1	910	.76	15	.01	112	.09	171	.13	5	.00	1273	24
2	2	0	0	21	.04	502	.92	13	.02	11	.02	547	1
MEANS	1	940	.76	15	.01	178	.15	91	.07	5	.00	1230	26
	2	0	0	18	.04	399	.91	10	.02	9	.02	436	2

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SHIFT	COMPONENTS THOR	COMP	RESP	ACC	EFFECTIVENESS
1	.76	.93	.87	1.00	.52
2	.61	.94	.89	1.00	.47
MEANS	.69	.94	.88	1.00	.49

ERROR SUMMARY - BY MESSAGE TYPE

SHIFT	MESS.G. TYPE	ERROR TYPE 1	2	3	4	ERROR RETURNS	INFORMATION LOSS UNITS	NUMBER OF MESSAGES
1	1	0	0	.1091	0	4.4727	0	55
1	2	"	0	0	0	5.8000	0	10
2	1	.1277	0	.1702	.0426	5.1915	0	47
2	2		0	0	0	4.6667	0	6
MEANS	1	.0638	0	.1397	.0213	4.8321	0	51
	2	"	0	0	0	5.2333	0	8

1 FTN 080 (STOP)

Figure 2-9a. Sample simulation shift summary continued.

SIMULATION OF 2-MAN (AO + UI( ) MESSAGE PROCESSING CHAIN 2

SUMMARY OF SHIFT DATA

MANPOWER UTILIZATION MEANS

SHIFT	TIME WORKED	PROP	TIME OTHER	MESSAGES PROCESSED	MEAN TIME PER MESSAGE	FINAL STRESS	FINAL ASPIRATION
1	1757	.49	1843	31	216	0	.926
2	922	.26	2678	17	212	.167	.914
MEANS	1339	.37	2261	24	214	.083	.920

TIME SEGMENTS

SHIFT	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	823	.75	15	.01	250	.23	10	.01	5	.00	1103	31
2	944	.75	16	.01	126	.10	165	.13	5	.00	1256	25
MEANS	883	.75	15	.01	188	.16	88	.07	5	.00	1180	28

SIMULATION OF 2-MAN (AO + UI(UU) MESSAGE PROCESSING CHAIN 2

TIME SEGMENTS

SHIFT	TYPE	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	1	849	.74	15	.01	250	.23	11	.01	5	.00	1089	26
1	2	895	.76	17	.01	247	.21	6	.01	6	.01	1172	5
2	1	976	.76	15	.01	103	.08	186	.14	5	.00	1286	22
2	2	864	.73	18	.01	294	.25	9	.01	7	.01	1192	3
MEANS	1	892	.75	15	.01	177	.15	98	.08	5	.00	1188	24
	2	860	.74	18	.01	270	.23	8	.01	7	.01	1182	4

Figure 2-9. Sample simulation shift summary.

TIME SEGMENTS

SHIFT	PRIOR	T1 TIME	T1 PROP	T2 TIME	T2 PROP	T3 TIME	T3 PROP	T4 TIME	T4 PROP	T5 TIME	T5 PROP	TOTAL (SUM)	N CPL
1	1	911	.77	15	.01	245	.21	10	.01	5	.00	1186	28
1	2	0	0	16	.05	296	.91	7	.02	6	.02	325	3
2	1	970	.76	15	.01	112	.09	171	.13	5	.00	1273	24
2	2	0	0	21	.04	502	.92	13	.02	11	.02	547	1
MEANS													
	1	940	.76	15	.01	178	.15	91	.07	5	.00	1230	26
	2	0	0	18	.04	399	.91	10	.02	9	.02	436	2

SHIFT	COMPONENTS THOR	COMP	RESP	ACC	EFFECTIVENESS
1	.76	.93	.87	1.00	.52
2	.61	.94	.89	1.00	.47
MEANS	.69	.94	.88	1.00	.49

ERROR SUMMARY - BY MESSAGE TYPE

SHIFT	MESS.G. TYPE	ERROR TYPE 1	2	3	4	ERROR RETURNS	INFORMATION LOSS UNITS	NUMBER OF MESSAGES
1	1	0	0	.1091	0	4.4727	0	55
1	2	0	0	0	0	5.8000	0	10
2	1	.1277	0	.1702	.0426	5.1915	0	47
2	2	0	0	0	0	4.6667	0	6
MEANS								
	1	.0638	0	.1397	.0213	4.8321	0	51
	2	0	0	0	0	5.2333	0	8

I FIN 060 (STOP)

Figure 2-9a. Sample simulation shift summary continued.

Table 2-2

Types of Simulation Output Listing

Listing	Figure
Basic input data	2-3
Task analytic data	2-3
Message backlog	2-4
Detailed message output	2-5
End of hour results	2-6
Results of NSHIFT iteration	2-7
Run summary	2-8
Shift summary	2-9

Enhancements were also effected in the content and format of the printed model output as follows:

1. On the Shift Summary

A. Manpower Utilization Results

- the shift number was added
- the "messages processed" column was retitled "msg units processed" to simplify and clarify its meaning
- a new row of total results for the IH hour shift was added
- a new row of grand means was added to show shift results for the average hour

B. Time Segment Results

- the title "N CPL" was clarified to read "TOTAL MESSAGES"

C. Error Summary Results

- the heading "number of messages" was corrected to read "number of message units"

2. Task Analytic Data

- A new printout was added after the listing of the task analyses to indicate the allocation of each task analysis to each operator type (IOD and G3) and to each message type.

3. Input Data

- A new printout was added after the hour parameters to show the new data on number of messages per stimulus message by message type.

CHAPTER III

THE INTERACTIVE MODEL

A second basic goal of the present work was to incorporate the capability for human participation to control and interact with the strengthened simulation model. To this end, the strengthened model was further modified, and additional program modules were designed and tested.

Figure 3-1 presents the basic data and system (procedural) flow for the interactive model. It indicates the general capabilities of the model, including:

1. use of computer disc for input and output data storage

2. capability to handle up to six interactive CRT terminals

3. background versus foreground mode on the CDC 3300 computer

4. capability to list input data and results

These capabilities allow an experimenter or supervisor to control simulation runs either with or without subjects inline. The interactive simulation combines, therefore, both physical simulation and computer simulation, taking advantage of the positive attributes of both. It allows the time compression and ease of variable manipulation afforded by computer simulation while, at the same time, including, through physical simulation, those aspects which cannot be easily or validly simulated through computer simulation methods. The end result is a hybrid simulation in which the digital computer simulates certain aspects of performance while online human operators perform other aspects, i. e., aspects not easily simulated through computer simulation.

An experimenter, seated at a terminal, can now perform the following:

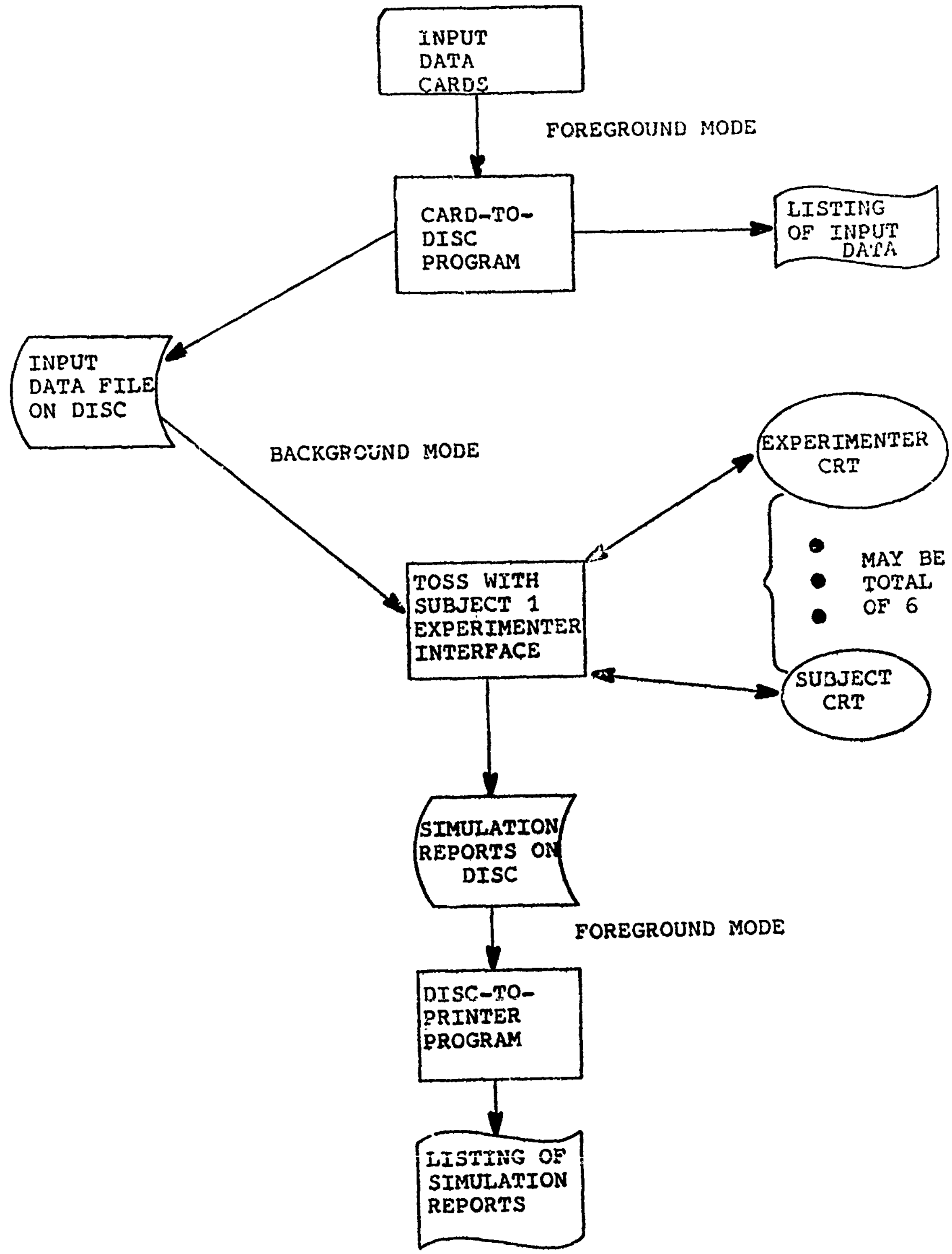

Figure 3-1. System flow for the interactive model.

1. select, enter, and verify run and operator parameters

2. specify number and cathode ray tube assignment of subjects

3. designate which tasks in a task analysis list a subject is to perform

4. monitor the messages generated and specify those which are to be performed by subjects

5. monitor results of each hour's processing by both computer simulation and subject

6. observe subject actions and indicate times of start and end of tasks

7. monitor subject performance times

The subject capability allows an actual subject, in line with the simulation, to perform selected tasks as designated by the experimenter. These tasks can be CRT monitoring, data entry, counting, composing, verifying, and the like.

The logic for the TOS simulation model presented in the prior Siegel, Wolf, and Leahy (1972) report has been revised to reflect the new interactive aspects and is presented here as Appendix C.

Displays Presented

A narrative description of the display capabilities which have been incorporated into the interactive model is now presented. This will serve to provide:

1. a functional description of the interactive changes in the TOS simulation model

2. a presentation of limitations and capabilities

3. a view of the various types of information displayed to the subject and the experimenter during the use of the interactive model

Prior to the simulation run and after reading and optionally recording the simulation inputs, Figure 3-2 is displayed for the general information of the experimenter.

```
GENERAL INSTRUCTIONS-
WHEN EXPERIMENTER INPUT IS REQUESTED...
        ENTER DATA
        DEPRESS RESET KEY
        DEPRESS SEND KEY

WHEN READY TO BEGIN DEPRESS SEND KEY
```

Figure 3-2. Initial experimenter instruction display.

This informational display is presented to the experimenter at the beginning of a simulation run.

The display shown in Figure 3-3 is presented to the experimenter only if the subject is to participate (i.e., the subject interface option (SBIN = 1) has been selected. The display enables the experimenter to enter the number of iterations for the first simulation run. The experimenter enters the value for ITER (in FORTRAN I2 format) immediately following the "=" character.

```
IF SUB. IS TO PERFORM, ENTER NUMBER OF
ITERATIONS FOR SUBJECT INTERFACE ITER = 1 BLANK
```

Figure 3-3. Iteration entry display

The next display, Figure 3-4, is also presented to the experimenter only if the subject interface option has been selected. Input values for each man in the simulation are displayed to the experimenter. For each man whose tasks are to be performed by a subject, the experimenter enters the subject console number (replacing the zero) in the CONSOLE column for the man.

OPERATOR PARAMETERS

MAN	CONSOLE	NAME	SPEED	ACCURACY	THRESHOLD	ASP.
1	0	A0-1	1.00	1.00	10.00	.900
2	0	-G3-	1.00	1.00	10.00	.900
3	0	I0D1	1.00	1.00	10.00	.911

ENTER APPROPRIATE CONSOLE NUMBER FOR EACH MAN WHO IS TO BE REPLACED BY A SUBJECT.

Figure 3-4. Console entry display.

The display shown in Figure 3-5 provides the experimenter with verification of data input in the preceding display. If an error is noticed, the experimenter enters YES immediately following the word CORRECTIONS and the display in Figure 3-4 is presented again. The computer program defaults to NO if no response is entered by the experimenter after ten seconds.

SUBJECT WILL PERFORM FOR 1 ITERATIONS
SUBJECTS WILL USE CRT'S AS FOLLOWS

MAN	CRT
1	2
2	0
3	0
4	0
5	0
6	0

ANY CORRECTIONS?

Figure 3-5. Experimenter confirmatory display.

Figure 3-6 presents the display which is presented to the experimenter only if subject console numbers have been entered in the display shown in Figure 3-4. An "X" is entered in the appropriate column for each task analysis which can involve subject interface. Either all, or some, of the task elements of a task analysis can be affected.

ENTER X FOR EACH TASK ANALYSIS TO BE PERFORMED BY A SUBJECT. IF ONLY PART OF A TASK ANALYSIS IS TO BE PERFORMED A LISTING BY TASK ELEMENT NUMBER WILL FOLLOW

TASK ANALYSIS

	1	2	3	4
ALL OF	/ /	/ /	/ /	/ /
PART OF	/ /	/ /	/ /	/ /

Figure 3-6. Task analytic selection display.

Figure 3-7 is a display presented to the experimenter for each task analysis for which some task elements involve subject interface. For each task element which may be performed by a subject, the experimenter replaces the appropriate S (for simulate) with a P (for perform).

TASK ANALYSIS 1
CHANGE S TO P FOR THOSE TASK ELEMENTS
TO BE PERFORMED BY THE SUBJECT

1	2	3	4	5	6	7	8	9	10
	S	S	S	S	S	S			
11	12	13	14	15	16	17	18	19	20

Figure 3-7. Task element selection display.

The display presented in Figure 3-8 allows verification of the inputs provided by the experimenter in the display of Figure 3-7. If corrections are necessary, the experimenter enters YES immediately following CORRECTIONS and Figure 3-7 display will be presented again. NO is the default response.

```
TASKPS (1,  1) = P        TASKPS (1,  2) = S
TASKPS (1,  3) = S        TASKPS (1,  4) = S
TASKPS (1,  5) = S        TASKPS (1,  6) = S
TASKPS (1,  7) = S        TASKPS (1,  8) =
TASKPS (1,  9) =          TASKPS (1, 10) =
TASKPS (1, 11) =          TASKPS (1, 12) =
TASKPS (1, 13) =          TASKPS (1, 14) =
TASKPS (1, 15) =          TASKPS (1, 16) =
TASKPS (1, 17) =          TASKPS (1, 18) =
TASKPS (1, 19) =          TASKPS (1, 20) =

ANY CORRECTIONS?
```

Figure 3-8. Task element verification display.

The next display, Figure 3-9, is presented to the experimenter at the beginning of each hour in a simulation run, if subject performance is to be affected. The display presents, in groups of eight, messages that have been generated for the hour. For each generated message that is to be replaced by a message in the input data, the identifying number of the prestored message replaces the zero in the MSG. NO. column. If appropriate, other columns containing descriptive information about the message should also be changed.

MESSAGES GENERATED FOR ACTION OFFICER FOR HOUR 1 TO INDICATE THAT A MESSAGE IS TO BE PERFORMED BY A SUBJECT, ENTER A PRESTORED MESSAGE NUMBER FOR THE REAL MESSAGE. ENTER ANY CHANGES IN APPROPRIATE COLUMNS.

ORDER	CUMUL. MSG. NO.	ARRIVAL (SECS)	PRIORITY	TYPE	LENGTH	COM. MSG. NO.
1	0	0	1	1	31	1
2	0	0	1	1	78	2
2	0	0	1	1	38	3
4	0	0	1	1	27	4
5	0	0	1	1	57	5
6	0	0	1	1	71	6
7	0	0	1	1	107	7
8	0	0	1	1	82	8

Figure 3-9. Message generation display.

Figure 3-10 shows the display provided to allow the experimenter to verify the previous input. Only the messages replacing simulation-generated messages are displayed. If an error is found, YES is entered immediately following CORRECTIONS, and the display shown in Figure 3-9 is presented again. NO is the default response.

NEW MESSAGES

CUMUL. ORDER	MSG. No.	ARRIVAL (SECS)	PRIOR	TYPE	LENGTH	COM MSG. NO.
1	2	0	1	1	31	1

Figure 3-10. Experimenter message generation verification display.

Figure 3-11 presents the information message displayed to the experimenter if the length of a prestored message varies more than one standard deviation from the mean for the message type.

PRESTORED MESSAGE 2 HAS 31 CHARACTERS
SIMULATION HAS GENERATED TYPE 1 MESSAGES
BASED ON MEAN = 65.00 STANDARD DEVIATION = 26.0
DEPRESS SEND KEY TO CONTINUE

Figure 3-11. Message length check message.

Figure 3-12 shows the informational message displayed to the experimenter if the input as shown in the display presented as Figure 3-9 has introduced more messages of a given type than the simulation would have generated (limited by FRET).

WITH THE PRESTORED MESSAGES REPLACING
SIMULATION - GENERATED MESSAGES, THERE
ARE 1 TYPE 2 MESSAGES INSTEAD OF THE
GENERATED 3

DEPRESS SEND TO CONTINUE

Figure 3-12. Message overgeneration display.

The information message similar to the preceding for message priority instead of message type is given in Figure 3-13.

WITH PRESTORED MESSAGES REPLACING
SIMULATION-GENERATED MESSAGES, THERE ARE
3 MESSAGES OF PRIORITY 1 INSTEAD OF THE
GENERATED 2 DEPRESS SEND TO CONTINUE

Figure 3-13. Message type overgeneration display.

Additional display messages are presented to the subject and/or experimenter to appraise him of status conditions or to request direction concerning future conduct of the experiments.

The display shown in Figure 3-14 indicates to the experimenter that a subject may be selected to process the next message. At this time, the experimenter may decide whether or not the subject is to perform. The experimenter enters YES or NO accordingly. The default response is NO.

MESSAGE NUMBER 1 IS TO BE PROCESSED BY
A0-1, MAN NUMBER 1
DO YOU WANT THE SUBJECT TO PERFORM?

Figure 3-14. Subject action display.

The next message advises the experimenter that he has selected the subject option for processing the indicated task element. If the task element requires the subject to enter a message on the CRT, then the experimenter enters YES as his response. NO is the default response.

READY FOR TASK ELEMENT 1 OF TASK ANALYSIS 1
IS SUBJECT TO ENTER MESSAGE ON CRT?

Figure 3-15. Subject option advisory display.

The next message (Figure 3-16) advises the experimenter to depress the SEND key when he signals the subject to begin performing the task indicated in the preceding display. (This message applies to the mode in which the experimenter observes subject performance.)

PLEASE DEPRESS SEND KEY WHEN SUBJECT BEGINS
TO PERFORM TASK ELEMENT

Figure 3-16. Task initiation display.

Immediately after the experimenter signals the system that the subject has begun performing the task element, the message presented as Figure 3-17 is displayed. The experimenter depresses the SEND key when he observes that the subject has completed the task.

PLEASE DEPRESS SEND KEY WHEN SUBJECT HAS
COMPLETED THIS TASK ELEMENT

Figure 3-17. Task completion display.

The display shown in Figure 3-18 is presented to the experimenter after the experimenter has signaled that the subject has completed the task. The experimenter enters the number of subject errors and his evaluation of subject performance (success/failure indicator).

PERFORMANCE TIME FOR SUBJECT = XX.XX SECONDS
ENTER NUMBER OF SUBJECT ERRORS -00
SUCCESS/FAILURE INDICATOR (S/F)
DEPRESS SEND KEY TO CONTINUE

Figure 3-18. Experimenter success/failure indication display.

The message shown in Figure 3-19 is displayed to the subject immediately after the experimenter enters a YES response to the query on whether or not the subject is required to enter a message on the display. The subject depresses the SEND key when he is prepared to begin.

THE NEXT DISPLAY WILL PRESENT A FORMAT TO YOU
YOU ARE TO ENTER APPROPRIATE MESSAGE ON THE CRT
DEPRESS SEND WHEN YOU HAVE COMPLETED THE MESSAGE

Figure 3-19. Subject entry advisory display.

A sample display of a TOS message format which is presented to the subject is shown in Figure 3-20. The subject enters his responses in the appropriate spaces. When he has completed entering the message, he depresses the SEND key. This enables the system to time the subject.

```
UGIC CON MEAS DATA MESSAGE OBJECTIVES
MSG-NR          PREC   SCTY   ORIG         RESTR (     )
UNIT-ID-OR-TF-NAME                            )
OBJ-1-NAME                   )TIME(              )
LOC(          ,         ,         ,        ,      ,-
----          ,         ,         )
RESP-UNIT(                        )
OBJ-2-NAME(                  )TIME(              )
LOC(          ,         ,         ,        ,      ,-
----          ,         ,         )
RESP-UNIT(                        )
OBJ-3-NAME(                  )TIME(              )
LOC(          ,         ,         ,        ,      ,-
----          ,         ,         )
RESP-UNIT(                        )
```

Figure 3-20. Sample message format.

For each incorrect subject response, the display shown in Figure 3-21 is presented after the subject has entered his responses. The incorrect responses are displayed to both the subject and experimenter.

RESPONSE B IS IN ERROR
SHOULD BE---
113000ZJAN73

SUBJECT RESPONSE WAS---

PLEASE DEPRESS SEND TO CONTINUE

Figure 3-21. Incorrect response display.

A display is also presented to the experimenter after all subject incorrect responses have been displayed. The experimenter enters his evaluation (S or F for success/failure indicator) and presses the SEND key. This display is shown in Figure 3-22.

PERFORMANCE TIME FOR SUBJECT = 87.80 SECONDS
NUMBER OF INCORRECT RESPONSES = 7
ENTER SUCCESS/FAILURE INDICATOR (S/F) -
DEPRESS SEND KEY TO CONTINUE

Figure 3-22. Experimenter evaluation display.

Table 3-1 shows the new subroutines and programs added in order to accomplish the interactive model.

Table 3-1

New Subroutines

SUBROUTINE NAME	FUNCTION OF SUBROUTINE
EXPER	Experimenter interface logic
SUBJEK	Subject interface logic
WDISP	Routes formats to CRT's and processes operator responses
DSOUT	Writes output record to disc for later print
DSIN	Reads card images from disc input file

CHAPTER IV

EVALUATION AND SENSITIVITY OF INTERACTIVE MODEL

One may reasonably ask whether or not an interactive simulation approach possesses any overall advantage when compared with a model which is confined to digital simulation methods. On the surface, it seems that certain aspects of human behavior cannot be simulated with any degree of veridicality through digital simulation. One reason for this may be that the data base regarding certain aspects of human performance may not be adequate. Another reason is that behavioral theory may not be sufficiently developed to allow an adequate digital representation. In these cases, the advantages of the hybrid approach are obvious. But what about the more general case?

Model Validity

According to Coombs et al., "the basic defining characteristic of all models is the representation of some aspects of the world by a more abstract system. In applying a model, the investigator identifies objects and relations in the world with some elements and relations in the formal system. Consequently, the model is regarded as an abstract representation of the world and the modeling process is called abstraction. When the model has been constructed, its consequences may be derived using the rules of logic and the available mathematical machinery" (1970, p. 2).

After completion of model construction, the formal process of verification (validation) can begin. Flowing from the application of the model are a set of logical consequences. These consequences are then taken, according to Coombs et al., as predictions to be compared with data. This stage of the interpretative process involves statistical assessment or verification since it requires a determination of the degree of correspondence between model output and the real world, as represented by data. Unfortunately, according Birnbaum (1973), the widely used statistic employed to assess the degree of fit, a correlation between model predictions and data, can be higher for incorrect models than for correct models. Usually, the examination of data from the real world will lead to modifications of the model since a model may contain a number of deficiencies, i. e., it may include irrelevant variables, it may exclude relevant variables, possibly relevant variables may have been evaluated inaccurately, and finally, the relationship between controlled and uncontrolled variables may be in error (Ackoff & Sasieni, 1968).

Figure 1, adapted from Coombs et al. (1970) and Obermayer (1964), attempts to summarize some of the relations among the various phases of the modeling process. From a logical point of view, according to Coombs et al. (1970), a model can only be rejected on the basis of data, not proven. A finding from a particular model may also be predicted from a variety of other models. Therefore, the presence of predictive validity in a particular model only provides some inductive support for the model. However, through a combined convergent and discriminant approach, an investigator can intensify inductive support for a particular model (Campbell & Fiske, 1959). While the Campbell and Fiske approach has been employed largely in the field of test validation, recent investigators have employed the method with considerable success in providing inductive support for a digital simulation model of a psychosocial system (Siegel, Lautman, & Wolf, 1972). Fortunately, the Campbell and Fiske methodology permits the use of both correlational and variance analytic methodologies. The combined methodologies provide considerable help in overcoming some of the goodness of fit problems associated with putting together and untangling the pieces of information which go into a model validation and its subsequent inductive support (Anderson, 1970, 1971; Birnbaum, 1973).

Unfortunately, none of these approaches resolve the practical problem of optimizing the selection among competing models designed for the same purpose. Shepard's (1964) paper on subjectively optimum selection among multiattribute alternatives presents a decision theoretic approach. Application of the Shepard methodology to the present problem will be made through an adaptation of a symposium paper presented by Edwards (1971).

Multiattribute Utility Scaling

The purpose of the Edward's technique in the present context is, ultimately, to provide a reasonable measure of the contribution of each of the modeling approaches to specified goals. Involved in the technique are two independent stages of measurement. When the results of these two stages are combined, a utility value for each of the competing approaches is acquired. As such, the technique represents one of several possible quantitative approaches to the evaluation of utility.

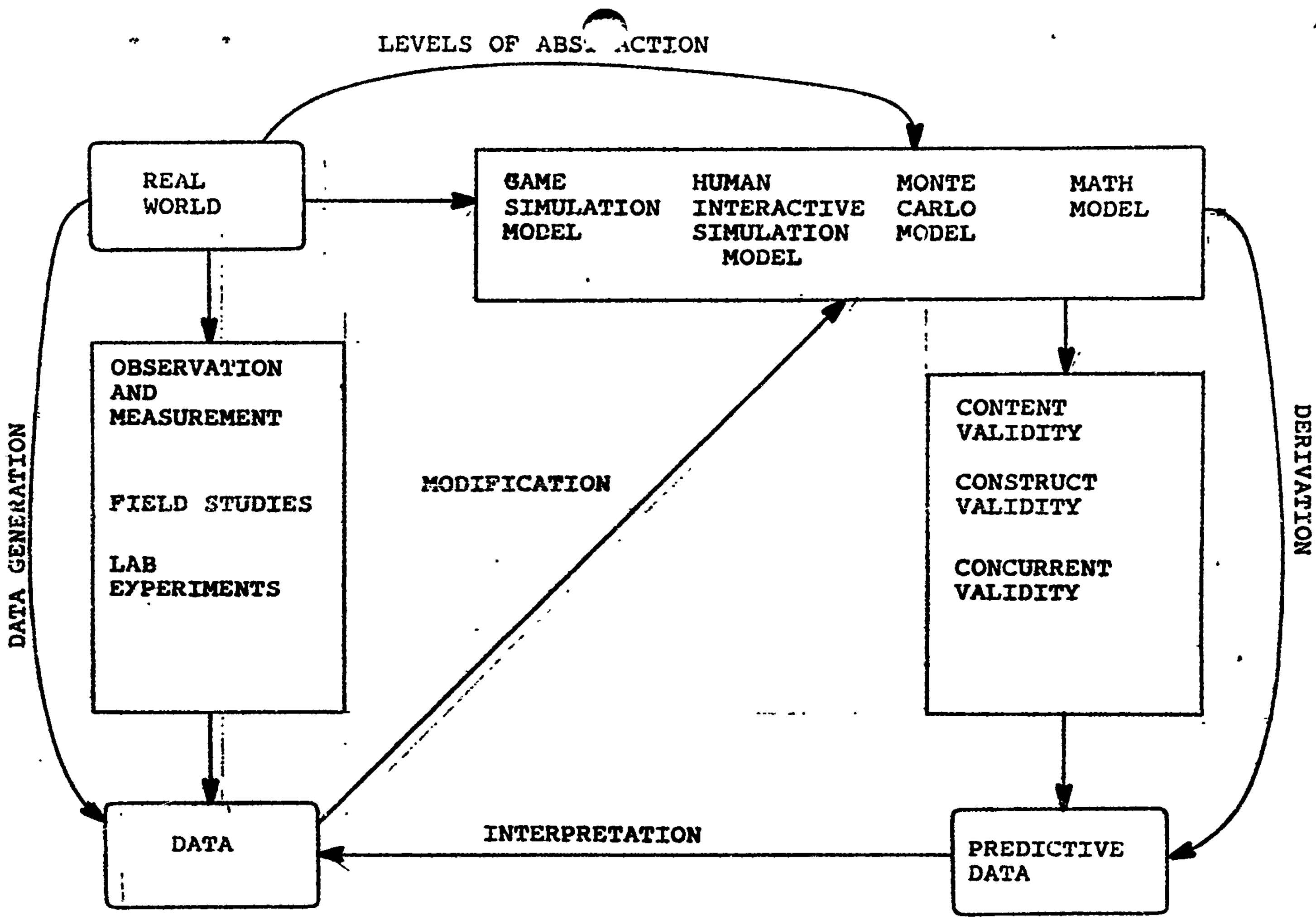

Figure 4.1 Schematic illustration of the modeling process adapted from Coombs et.al. (1920) and Obermayer (1964).

Scaling the Importance of Model Attributes

The first stage of the measurement of utility requires a delineation of the attributes of models to be scaled in terms of their relative importance to specified goals, e.g., prediction, information, system design, feasibility demonstration, subsystem comparison, training, analysis, etc. One set of model attributes might be:

construct validity
repeatability of output
degree of error/low variability
feasibility of use and application
content validity/real world detail
low confounding of variables
sensitivity/input-output
low number of assumptions/parsimony
generality/flexibility of application
modifiability

Other attribute listings relative to simulation models have been developed by Meister (undated) and Siegel (1970). Once the attributes have been specified, they can be assigned numerical values that represent their relative importance for the specified goal which, in the present case, has been left undefined since the approaches to be evaluated are both assumed to have been designed for the same purpose.

Rating the Attributes of Models

Two expert judges rated each of the above listed model attributes without reference to a specified goal. The procedure began with ranking the attributes from most important to least important. Then, the least important dimension was assigned a value of 10, and the remaining nine attributes (dimensions of value) were assigned values by magnitude estimation. Alternatively stated, numbers were assigned to develop a ratio scale based on the anchor value of 10 for the least important attribute. When this task was completed, the sum of the numbers assigned to all ten attributes was obtained, and the value assigned to each was divided by this sum. In this way, scale values were converted into proportions of total importance contributed by each of the ten attributes. Emerging from this procedure was a set of numbers with properties rather like probabilities. The magnitude estimations of the two judges were averaged prior to the computation of proportions.

Weighting Models on Dimensions of Value

The second stage of measurement involved a determination of the location of each approach being evaluated on each of the dimensions of value. This measurement was accomplished by asking an appropriate expert to estimate for each attribute the position of each approach on a 0-100 scale of plausibility, alternatively expressed as the ease by which the model builder could achieve each desired dimension of value for each model. Zero was defined as the minimum plausible value and 100 was defined as the maximum plausible value.

Combining the Stages: Calculation of Utilities

Calculation of the aggregate utilities was accomplished in accordance with the equation given by Edwards:

$$U_i = \sum_j (w_j u_{ij})$$

where $$\sum_j w_j = 1.00$$

and $$u_i = (w_j u_{ij})$$

The aggregate utility for the i^{th} approach is represented by U; w_j is the importance weight of the j^{th} dimension of value; u_{ij} is the scaled position of the i^{th} model on the j^{th} dimension of value. In words, the final result of the scaling procedure consisted of one aggregate utility for each approach evaluated--interactive or completely digital. Since only two modeling approaches were evaluated in this manner, selection among the competing models designed for the same purpose may be based on maximization of U_i. Alternatively stated, the approach with the highest aggregate utility is identified as more desirable in general or on the overall.

Results

The utilities so derived for each of the two modeling approaches are presented in Table 4-1. An inspection of Table 4-1 indicates a slight superiority of the completely digital over the interactive simulation approach.

Table 4-1

Calculated Utilities for Two Simulation Approaches

Dimension of Value	w_j	Interactive U_i	Completely Digital U_i
Construct validity	.18	9	5
Repeatability of output	.16	13	16
Degree of error/low variability	.14	4	7
Feasibility of use and application	.13	8	12
Content validity/real world detail	.12	10	7
Low confounding of variables	.10	3	5
Sensitivity/input-output	.08	5	6
Low number of assumptions/parsimony	.04	4	2
Generality/flexibility of applicant	.03	2	1
Modifiability	.02	1	2
ΣU_i = Aggregate utility =		59	63

Note: U_{ij} is not presented in this table.

While the completely digital approach showed a slight superiority over the interactive simulation approach in terms of aggregate utility across all dimensions of value, there was considerable variation among the approaches when examined at the level of their utilities on individual dimensions. The interactive approach showed higher utility for the dimensions of construct validity, content validity/real world detail, parsimony/low number of assumptions, and generality/flexibility of application. For all other dimensions, the completely digital approach showed higher utility. The slight superiority of the completely digital approach resulted largely because it had higher utilities for the attributes of models judged to be more important, i.e., repeatability of output, degree of error/low variability, and feasibility of use and application.

Since the present application of Edwards' approach left the goal or purpose of the approaches under consideration undefined, the results presented in Table 4-1 could easily change with appropriate goal definition.

Sensitivity Tests

In order to verify the acceptability of the program and logic changes incorporated into the basic model to produce the strengthened model, seven test computer runs were made. The results and implications of these runs are presented in this section. The basic input data for the model were essentially the same as those used in the six operator case described in the prior report (Siegel, Wolf, & Leahy, 1972); this situation is called run 1 or the baseline run.

Figure 2-2 shows the parametric input and Figure 2-3 contains the task analytic data for all seven runs. Parameters varied in these test runs are those which would be expected to exercise those portions of the model which were enhanced to generate the strengthened model.

Table 4-2 shows the parameters which were modified during the runs: operator precision, number of messages per stimulus message, message frequency by priority, and operator speed. The results for each condition will be discussed independently.

Precision

Parameter values of high operator precision (0.85) and low operator precision (1.15) were run. The results from these runs may be compared with the baseline (precision = 1.00) run results (see Figure 4-2). The simulated high precision crew worked about 12 per cent less time to process the same workload as a crew of nominal precision. However, an increase of about 150 per cent in time worked was shown for the very imprecise crew. This is due to the fact that, within the model, the probability of task failure approaches infinity as precision approaches its lowest value (1.20). For a value of precision = 1.15, task failures are far more frequent than successes. As a result, the average time to process a message jumped to 2640 seconds as opposed to 550 seconds for the baseline runs and fell to 515 seconds for the high precision crew. Also, as expected, the average final stress was directly related to precision. A 3 to 1 simulated stress change was exhibited from low to high precision. The simulated low precision group had a final stress of .147, while the high precision group had a final stress of .049.

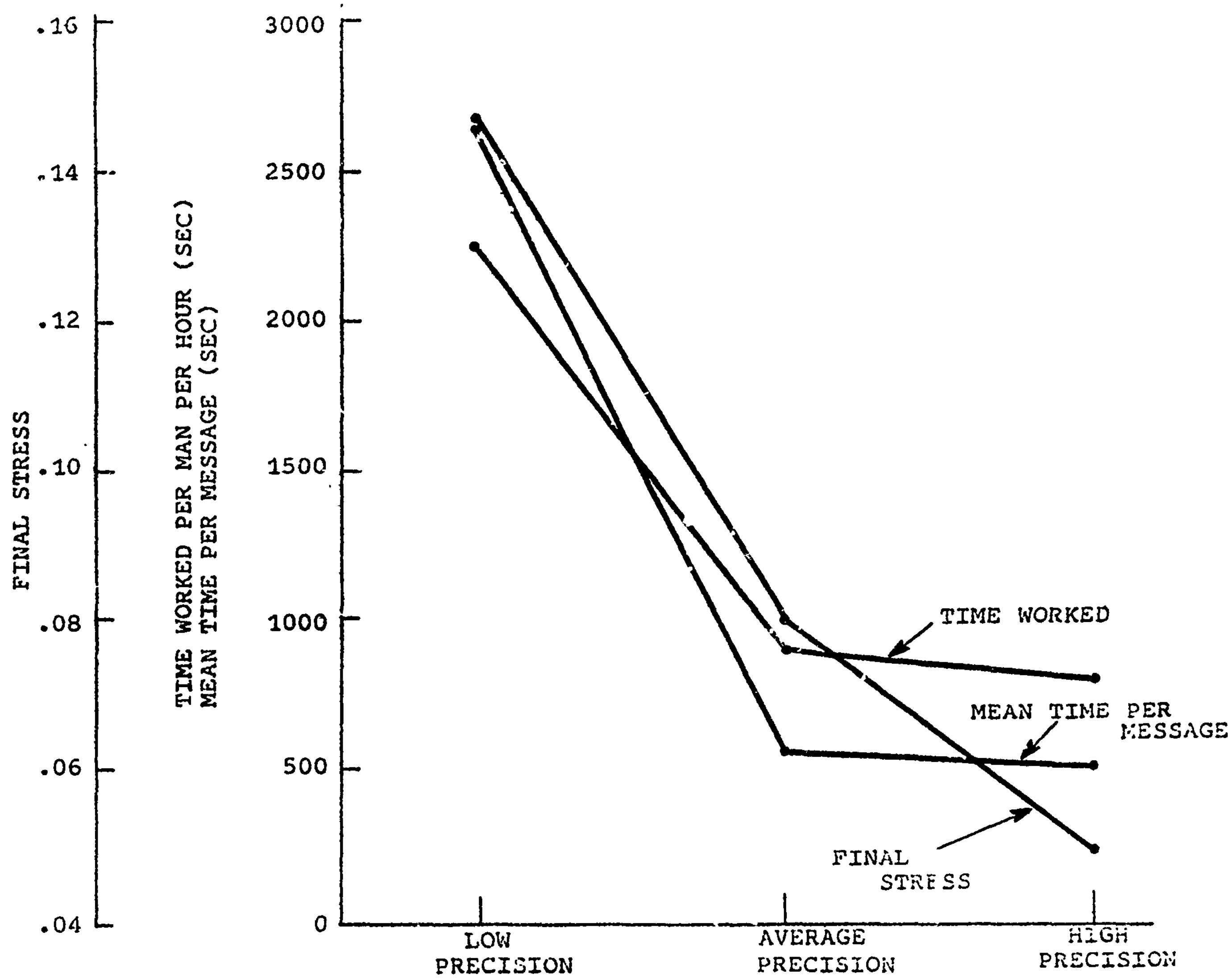

Figure 4-2. Effect of operator precision on mean time per hour worked and on mean time per message.

Table 4-2

Sensitivity Test Parameters

Run	Precision	No. of Mgs Per Type 1 Stimulus Messages	Msg Frequency by Priority					Operator Speed
			1	2	3	4	5	
1 (Baseline)	1.00	0	70	20	10	0	0	1.00
2	0.85	0	70	20	70	0	0	1.00
3	1.15	0	70	20	10	0	0	1.00
4	1.00	3	70	20	10	0	0	1.00
5	1.00	0	30	10	10	20	30	1.00
6	1.00	0	70	20	10	0	0	0.85
7	1.00	0	70	20	10	0	0	1.15

Figure 4-3 displays the four effectiveness components and the composite effectiveness as a function of simulated operator precision. It is apparent that precision, as simulated, impacts simulated system effectiveness to a considerable degree. The simulated high precision crew had a thoroughness rating of .92. The nominal or baseline crew exhibited a minimal reduction to .91, but the thoroughness of the simulated low precision crew was indicated to be .65.

For the completeness component of effectiveness, the results were similar with the high precision group receiving a value of .70, the baseline group .65, and the simulated low precision group dropping to .25.

For the responsiveness component of effectiveness, the trend was stronger. The simulated high precision group value was .83, the average group value .79, and the low precision group received a responsiveness value at .03.

The accuracy effectiveness component indicated the least change as a function of simulated operator precision. The low and nominal precision simulated groups both indicated an accuracy of .49, while the high precision operators indicated an accuracy of .55. However, we note that quite low undetected error probabilities were input and, as a result, the effects of precision on accuracy are minimized.

For the overall or composite effectiveness score, the high precision simulated crew effectiveness was .73, the average crew effectiveness was also .73, while the low precision crew composite effectiveness was .13.

Number of Messages Per Stimulus Message

Run 4 was made to exercise the new model logic which permits multiple TOS input message generation for each stimulus message. Each communication submitted to the action officer is considered a stimulus message. (Note that the secondarily generated messages are not restricted to the original message type but are given a type number in the same prearranged proportion as any new message.) In run 4, three messages were to be generated (on the average) for each type 1 stimulus message entering the system. In the baseline run, 65 type 1 messages and a total of 397 messages were processed. Thus, an additional 2 x 65 = 130 messages (a total of 527) would be expected to be generated in run 4. The numbers of messages used represent totals over 10 iterations. Actually, 513 were processed (as shown in Table 4-3) indicating acceptable program operation in view of random effects during the 10 iteration runs:

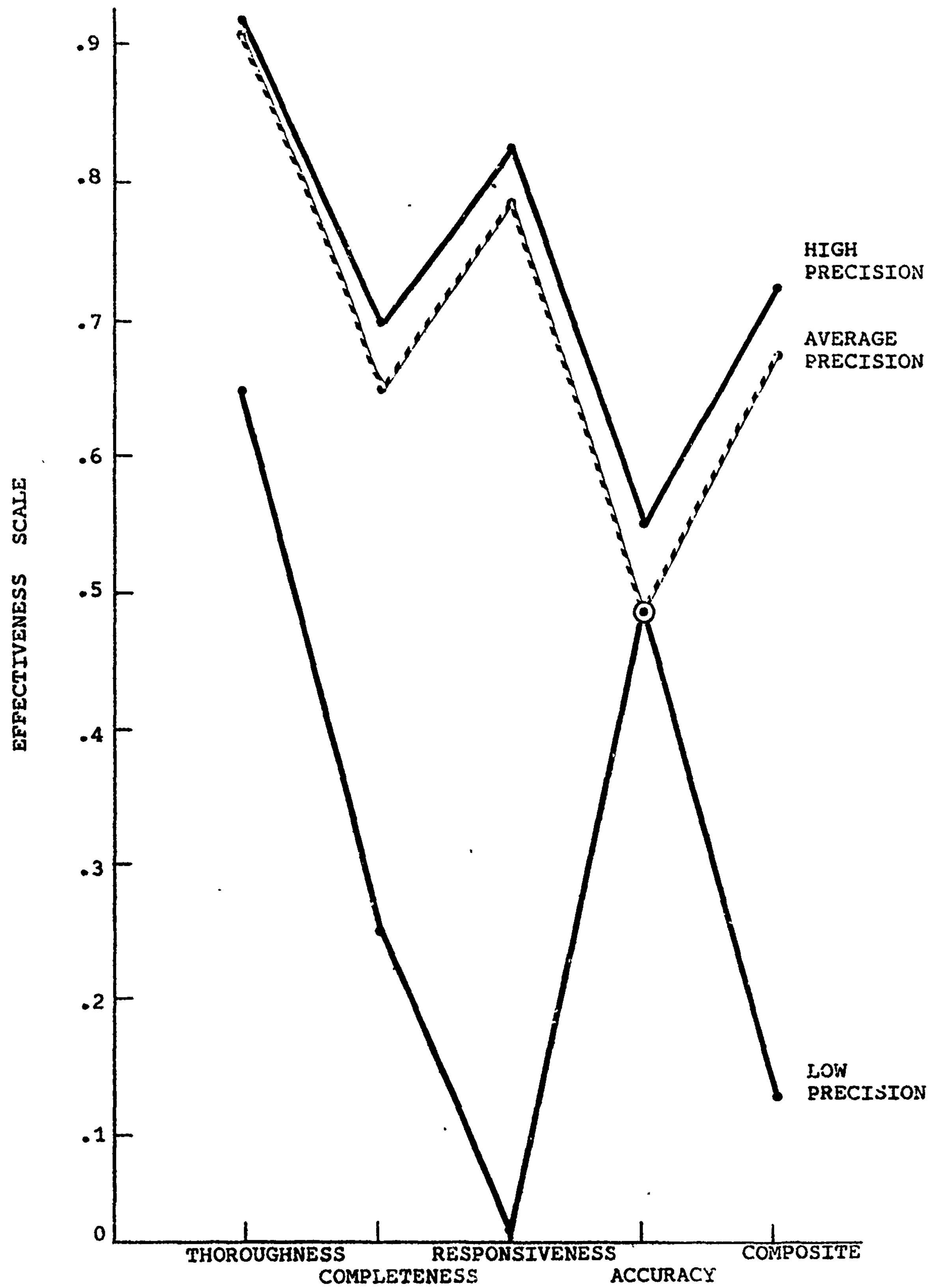

Figure 4-3. Effects of operator precision on effectiveness measures.

Table 4-3

Results of Message Generation Modification

Message Type	Baseline	Run 4
1	65	78
2	102	127
3	29	56
4	136	176
5	57	67
6	6	3
7	2	6

As a result of the increased message load, time worked was about 30% larger than the baseline run and average final stress increased from 0.08 to 0.12. Moreover, the processing time per message also increased 30 per cent. Overall effectiveness was only insignificantly affected.

However, as anticipated, there was an increase in time (140 seconds as opposed to a baseline value of 41 seconds) for message in-queue time. This effect was expected because of the increased number of messages which arrive at the same time.

Effect of Message Priorities

Run 5 was completed to ensure that the proper effect on stress was achieved by relatively large numbers of high priority messages. A total of 394 messages was processed in run 5. The input probabilities of the five types of priority (Table 4-2) were .30, .10, .10, .20, .30. Accordingly, the expected number of messages by priority is 118, 39, 39, 79, and 118. This is acceptably close to the actual results: 124, 34, 44, 77, and 115, based on the fact that selection of a message priority is also dependent on pseudorandom processes.

As would be expected, little change from nominal was evidenced in this run in the number of messages processed (897 to 889) or in overall effectiveness (.68 as compared with .66), but average terminal stress was sharply higher--increasing from 0.08 to 0.47. This result for stress is in the expected direction since higher priority messages are anticipated to yield higher operator stress.

It is noted that the stress buildup was almost exclusively on the simulated G-3 and AO. For these two operatcrs, the combined final stress was 0.82, whereas the value of 0.11 resulted for the UIODs.

Operator Speed

The anticipated effects of operator speed on time worked and other factors was noted. Figure 4-4 shows the increase in work time, stress, and average time per message unit and the decline in effectiveness as the operator speed.

Operator speed would also be expected to affect the responsiveness component of the effectiveness measure. In fact, as operator speed increased from the slow speed (1.15) to the baseline speed (1.0), and then to the fast speed (.85), responsiveness increased from .67 to .79 and to .86.

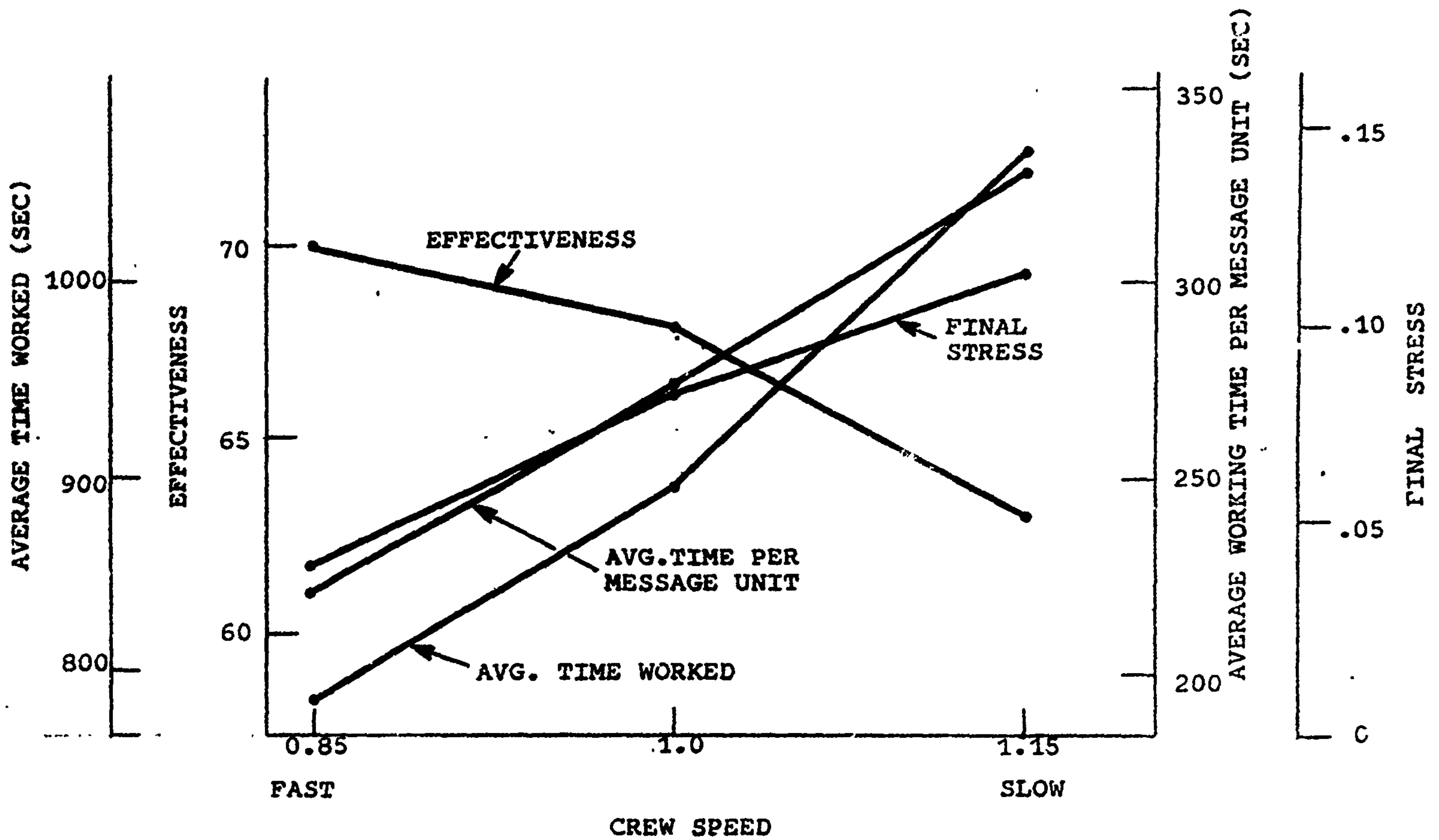

Figure 4-4. Effect of operator speed on overall effectiveness, final stress, average working time per message unit, and average time worked.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study attempted to achieve two purposes: (1) to extend a previously developed digital model for simulating the acts and behaviors of the operators in the TOS system, and (2) to strengthen the previously developed model by incorporating a number of new features and enhancements.

The extension involved modification of a previously developed completely digital computer based simulation so as to allow "hybrid" simulation in a man-computer interactive manner. In this hybrio or interactive simulation, a man sitting at a cathode ray tube terminal can be assigned the performance of those tasks which are best not treated through digital simulation while the computer simulates the performance of tasks which digitel simulation treats well. The simulation is termed hybrid since the human can be considered to be an analog device which performs in interaction with the digital logic of a high speed computer. The end result is an interactive simulation which takes advantage of the time compression of the digital computer and allows inclusion of the flexibility of the human components in a man/machine system.

The prior model was modified, to this end, in two ways. First, the required programming was completed to allow one or more subjects to participate in a TOS exercise by performing specific TOS tasks. The tasks to be performed by the online subject are prespecified by the person charged with simulation conduct and can include such tasks as cathode ray tube monitoring, data entry, data comparison, counting, verifying, and decision making. Second, the original model was extended to allow the experimenter to interact with the program and make online changes such as: parameter modification, assignments of subjects and the tasks they perform, and characteristics of messages and message frequency.

To achieve the second purpose of the study, strengthening of the previously developed digital simulation model, a number of model elaborations were developed and programmed. The principal elaborations included: (1) extension of the number of shifts which can be simulated, (2) revision of the calculation of performance effectiveness, (3) extension to allow the generation of more than one TOS message from a single system input message,

(4) correction in the calculation of the number of undetected errors, (5) modification of the calculation of operator stress to allow consideration of the effects of message priority on stress, and (6) improvement in the content and format of the printed output.

The effects of the modifications on the TOS simulation model's output were tested through a set of sensitivity tests. The results suggested that the modifications produce reasonable output (i. e., in conformity with logical expectation).

Conclusion

It appears that either the strengthened or the interactive model may now be employed for testing various approaches to the employment of system operators within the TOS system. It is believed that the simulation models will yield results which are sufficiently sensitive to yield statements relative to preferred approaches among alternatives, as well as extent of superiority from the points of view of the effectiveness criteria built into the model.

Finally, we note that the model has not been validated (in the psychometric sense) and that such validation is possibly always warranted.

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APPENDIX A

Strengthened TOS Model User's Manual

This appendix presents the information required by the user of the strengthened TOS simulation model in preparing his data for the computer and in running the TOS model. Included are the card input formats, card sequences, variables and subscript lists, and the like. The program is written in the FORTRAN IV language for implementation on the CDC 3300 digital computer.

Principal Subscripts

Table A-1 shows the principal FORTRAN subscripts used for indexing computer dimensioned variables. For each FORTRAN subscript, the actual variable name and present maximum value is shown. Without computer program changes, the computer model cannot handle cases where the variables exceed these maximum values. These subscripts are also used in some cases as variables in their own right.

Also included here are the assignments for the 5 priority codes (IP), 2 operator type codes (J), 4 effectiveness components (NEC), 6 man number assignments (M), 4 error type codes (IE), and 7 message type codes (IT).

Table A-1

Principal Model Subscript Variables

Variable	Subscript FORTRAN	Maximum Value	Maximum Value FORTRAN
Hour Number	IH	15	IHMAX
Iteration Number	NSHF	100	NSHIFT
Message Number (Cumulative)	CMSG	200	
Priority Number	IP	5	
1 - routine			
2 - priority			
3 - operational immediate			
4 - flash			
5 - presidential interrupt			
Task Element Number	I	20	
Task Analysis Number	K	4	
Operator Type	J	2	
1 - G3 and Action Officer			
2 - IOD			
Effectiveness Component Number	NEC	4	
1 - thoroughness			
2 - completeness			
3 - responsiveness			
4 - accuracy			
Man Number	M	6	MEN(3)
MEN(1) : Action Officers & G3s (G3 is MEN(1))			
MEN(2) : IOD operators			
Error Type	IE	4	
1 - commission			
2 - typographic (includes abbreviation & spacing)			
3 - omission			
4 - other			
Message Type	IT	8	
1 - add data			
2 - change data			
3 - delete data			
4 - query			
5 - relay			
6 - special process request			
7 - standing request for information			

Card Types and Function

Table A-2 presents the data and type sequence for inputing the TOS simulation model computer program. There are 18 card types. All of the first 17 must be present in the first simulation run of a series. After the first run of a series, it is not necessary to repeat all of the input data for subsequent runs, if the previous inputed data can be used. Card types 3, 6, 9, 11, 14, and 16 control this option of bypassing the inputing of specific types of information.

The order of data cards within a run is critical. A single card type out of sequence will, at best, yield a faulty run.

Table A-3 presents the data found on card types 1 and 2. Neither of these card types may be omitted from the input deck. Card type 1 provides 72 columns for a prose description of the mission to be simulated. This prose description called INDENT will be printed at the top of each page of program output.

Card type 2 contains the simulation parameters for this computer run. In this data card, as in all cards, where multiple columns are allocated (except for alphabetic entries), the entry must be right justified. For example, on card 2, the first entry is NSHIFT in columns 1 to 3. If only one iteration is desired, this entry must be punched in column 3. If the one is placed in column 2 with nothing in column 3, it will be interpreted as 10. Preceding blanks, on the other hand, are ignored. Table A-3 also describes the purpose of each entry.

The total of MEN(1) and MEN(2) cannot be larger than 6, within present program constraints.

The output recording options (ORD's) allow a flexibility between exact detailing of each task element processing and errors committed to general run summaries. Intermediate options, as shown in Table A-3, have a great effect on printout time, and may, therefore, be bypassed when computer processing time is limited. The run summaries are not optional, but are always printed. The run summaries include tables for manpower utilization data, message processing trimming, effectiveness data, workload summary data, and error summary data.

Table A-2

Input Card Sequence for TOS Simulation Program

Order (card type)	Description of Input Card Contents/Function
1	Mission title
2	Simulation parameters
3	Read or skip operator parameters
4	Names of operators
5	Operator parameters (one card per operator)
6	Read or skip hour parameters
7	Names of message types
8	Hour parameters (one card f· each hour)
9	Read or skip error data
10	Error data (one card for each of 3 error types)
11	Read or skip message length data
12	Message length means
13	Mesage length standard deviations
14	Read or skip task analysis
15	Task analysis (one card for each task element)
16	Read or skip effectiveness components
17	Effectiveness components
18	Repeat for new run or end

Table A-3

Input--Mission Identification and Simulation Parameters

	Card Columns
Mission Title(card type 1)	
IDENT-A run descriptor of up to 72 characters is printed on the top of each page of printout followed by the page number	1-72
Simulation Parameters(card type 2)	
NSHIFT-Number of repetitions or iterations of this mission before summary data are prepared	1-3
IHMAX-Number of hours per shift(determines the number of type 6 cards to be read)	4-5
MEN(1)-Number of operators of type 1, number of action officers including G-3. The highest numbered AO is the G-3	6
MEN(2)-Number of operators of type 2, number of input/output device (IOD) operators. The sum of MEN(1)+MEN(2) determines the number of type 5 cards to be read in	7
ORO(1)-Output recording option number 1 If equal 1 print input data	10
ORO(2)-Output recording option number 2 If equal to 1 print hourly message queue	11
ORO(3)-Not used	12
ORO(4)-Output recording option 4 If equal to 1 print detail task element processing	13
ORO(5)-Output recording option 5 If equal to 1 print message processing	14
ORO(6)-Output recording option 6 If equal to 1 print hour and iteration summary	15
ORO(7)-Not used	16
ORO(8)-Not used	17
ORO(9)-Not used	18
ORO(10)-Not used	19
IDAY-Day of mission simulated	20
BKLG-Number of messages in AO/G3 inbox at the beginning of the shift	21-22
PUL-Probability of a non important undetected error in the central computer complex data store	25-29
PUS-Probability of a significant error in the central computer complex data store	30-34
SRTA-System response time to an inquiry	35-39
SRTS-Standard deviation of the system response time to an inquiry	40-44
IATA(1,1)-Task analysis to be used for operator type 1 message type 1	45
IATA(1,2)-Same as above but for message type 2	46
IATA(1,3)-Same as above but for message type 3	47
IATA(1,4)-Same as above but for message type 4	48
IATA(1,5)-Same as above but for message type 5	49
IATA(1,6)-Same as above but for message type 6	50
IATA(1,7)-Same as above but for message type 7	51
IATA(1,8)-Same as above but for message type 8	52
IATA(2,1)-Operator type 2, message type 1	53
IATA(2,2)-Operator type 2, message type 2	54
IATA(2,3)-Operator type 2, message type 3	55
IATA(2,4)-Operator type 2, message type 4	56
IATA(2,5)-Operator type 2, message type 5	57
IATA(2,6)-Operator type 2, message type 6	58
IATA(2,7)-Operator type 2, message type 7	59
IATA(2,8)-Operator type 2, message type 8	60
NTE-Number of task elements over all task analyses to be used (determines the number of type 15 cards to be read in)	61-63
Y-Random number to be used to initialize random number generator. An eight digit positive odd octal number must be used	65-71
ICHAIN-Shift number for this run if chaining option is being utilized (ICHAIN=1 for first shift,0 if no chaining)	76
TZERO-Time at start of shift being simulated	77-80

The variable IDAY determines the day number of a simulation with reference to the number of continuous days worked at this task and is used within the model to trigger fatigue effects.

The variable matrix IATA determines which task analysis (i.e., procedure) will be used in the processing of a message. It is presently limited to a maximum of four task analyses. None of these may have more than 20 task elements.

Table A-4 shows the card formats for card types 3,4, and 5. Card type 3 determines whether or not new operator description data will be read in. Card type 4 specifies the four character names of the known operators (i.e., UIOD, etc.). One card type 5 is required to describe each of the operators called for on card type 2. Since the man number is on each card, ordering of these cards is not required.

Table A-5 describes the data for card types 6, 7, and 8. Card type 6 determines whether or not new hour parameters will be read. Card type 7 provides for the readin of names for each of seven message types. Each name consists of four characters. This name will be printed out in detailed message processing if this option is called. For every hour to be simulated, on card of type 8 must appear. The hour parameters include message workload, message type frequency, message priority distribution, and message frequency of arrival. The type 8 cards need not be ordered since the hour is specified on each card.

Table A-6 shows the card formats for card types 9 and 10. Card type 9 determines whether or not error data (i.e., card type 10) is read in or not. Card type 10 contains the error rate data for each message type of each error type. Error originator probabilities are also shown. Card types 10 do not have to be in order of error since error type is specified on each card.

Table A-7 shows the format for card types 11, 12, and 13. Card type 11 determines whether or not message length data (i.e., card types 12 and 13) will be read in or not. Card type 12 contains the mean message length data for each message type. Card type 13 contains the message length deviation data for each message type.

Table A-8 shows the card formats for card types 14 and 15. Card type 14 determines whether or not task analytic data (i.e., card type 15) will be read in or not. One card type 15 must be input for each task element in the task analysis, as specified by NTE in card type 2. The card type 15 contains all timing and sequencing data required to simulate a task element.

Table A-4

Input--Operator Parameters

Read or skip operator parameters(card type 3)

		Card Columns
ISKIP-	If equal to 1 skip to reading card type 6. If not equal to 1 read card types 4 and 5	1

Names of operators(card type 4). Reads in one four character name for each of the men specified in card type 2.

		Card Columns
NAME(1)-	Name of operator number 1	1-4
NAME(2)-	Name of operator two	5-8
NAME(M)-	Name of operator M	

Operator parameters(card type 5). One card is read in for each man specified in card type 2.

		Card Columns
M-	Man number	1
F(M)-	The speed factor of this man. An average man is 1.0, a faster than average man has an F(M) value less than 1.0. A slower than average man has an F(M) value greater than 1.0	5-9
PREC(M)-	The precision factor of this man. An average man who makes an average number of errors would have a precision factor of 1.0. A highly precise man who makes many fewer than average errors would have a precision factor of 0.9. Perfection is represented by a value of 0.8 and complete failure which would result in unending runs is represented by a value of 1.2	10-14
STRM(M)-	The stress threshold of this man. The number of priority messages in the backlog for this man which will produce a maximum effort	15-19
ASP(M)-	The level of aspiration of this man. An aspiration of 1.0 represents striving for perfection	20-24

Table A-5

Input--Hour Parameters

	Card Columns
Read or skip hour parameters(card type 6)	
ISKIP- If equal to 1 skip card type 9, If not equal to 1, read card types 7 and 8	1
Names of message types(card type 7)	
NMTYP(1)-Name of message type 1	1-4
NMTYP(2)-Name of message type 2	5-8
NMTYP(3)-Name of message type 3	9-12
NMTYP(4)-Name of message type 4	13-16
NMTYP(5)-Name of message type 5	17-20
NMTYP(6)-Name of message type 6	21-24
NMTYP(7)-Name of message type 7	25-28
Hour parameters(card type 8) One card for each hour specified in card type 2 by IHMAX.	
IH-Hour number	1-2
IGP(IH)-Number of messages arriving in AO/G3's inbox in the last 15 minutes of this hour	3-4
IGR(IH)-Number of messages arriving in AO/G3's inbox randomly throughout this hour	5-6
IUR(IH)-Non functional	7-8
FRET(1,IH)-Cumulative proportional occurrence of message type 1 - add	10-14
FRET(2,IH)-Type 2-change	15-19
FRET(3,IH)-Type 3-delete	20-24
FRET(4,IH)-Type 4-query	25-29
FRET(5,IH)-Type 5-relay	30-34
FRET(6,IH)-Type 6-SPR	35-39
FRET(7,IH)-Type 7-SRI	40-44
FREP(1,IH)-Cumulative proportion of message occurrence of priority type 1-routine	45-49
FREP(2,IH)-Priority type 2-priority	50-54
FREP(3,IH)-Priority type 3-operational immediate	55-59
FREP(4,IH)-Priority type 4-flash	60-64
FREP(5,IH)-Priority type 5-presidential interrupt	65-69
FRER(IH)-Frequency of routine message arrival per hour	70-74
FREO(IH)-Frequency of arrival of other than routine messages per hour	75-79
Messages per stimulus data(card type 7.5)	
RMPS(1)-Number of messages expected per stimulus for message type 1	1-5
RMPS(2)-Number of messages expected per stimulus for message type 2	6-10
RPMS(3)-Number of messages expected per stimulus for message type 3	11-15
RPMS(4)-Number of messages expected per stimulus for message type 4	16-20
RPMS(5)-Number of messages expected per stimulus for message type 5	21-25
RPMS(6)-Number of messages expected per stimulus for message type 6	26-30
RPMS(7)-Number of messages expected per stimulus for message type 7	31-35

Table A-6

Input--Error Data

	Card Columns
Read or skip error data(card type 9)	
ISKIP- If equal to 1 skip to card type 11, If not equal to 1, read card type 10	1
Error data(card type 10)	
IE- Type of error. 1=commission,2=abbreviation, typographical or spacing, 3=omission	1
ER(IE,1)-Error rate per 100 characters of message type 1	2-9
ER(IE,2)-Message type 2	10-17
ER(IE,3)-Message type 3	18-25
ER(IE,4)-Message type 4	26-33
ER(IE,5)-Message type 5	34-41
ER(IE,6)-Message type 6	42-49
ER(IE,7)-Message type 7	50-57
ER(IE,8)-Non functional	58-65
ERPG-Percentage of G3/AO errors which produce error routines	66-72
ERPI-Percentage of VIOD errors which produce error routines	73-79

Table A-7

Input--Message Length Data

	Card Columns
Read or skip message length data(card type 11)	
ISKIP-If equal to 1, skip card type 14 If not equal to 1, read card types 12 and 13	1
Read message length means(card type 12)	
INC(1)-Number of characters in transformed message type 1	1-9
INC(2)-Message type 2	10-19
INC(3)-Message type 3	20-29
INC(4)-Message type 4	30-39
INC(5)-Message type 5	40-49
INC(6)-Message type 6	50-59
INC(7)-Message type 7	60-69
INC(8)-Non functional	70-79
Read message length standard deviations(card type 13)	
INS(1)-Standard deviation of characters in transformed message type 1	1-9
INS(2)-Message type 2	10-19
INS(3)-Message type 3	20-29
INS(4)-Message type 4	30-39
INS(5)-Message type 5	40-49
INS(6)-Message type 6	50-59
INS(7)-Message type 7	60-69
INS(8)-Non functional	70-79

Table A-8

Input--Task Analytic Data

Card Columns

Read or skip task analysis(card type 14)

ISKIP-	If equal to 1, skip card type 16. If not equal to 1, read card type 15.	1

Task analysis(card type 15)
One card for each task element specified by NTE in card type 2.

K-	Task analysis number	1-2
I-	Task element number within this task analysis	3-5
JTYPE(I,K)-	Task element type where 1=a task element on which the message may be rejected with a probability specified by AVPROB(I,K), 2=a task element in which the number of characters for this message type will be multiplied times the stochastically determined mean time to produce the time required to transform the message, 3= a decision task element where operator factors such as speed [F(M)], precision [PREC(M)], and stress level [STR(M)] are not allowed to affect the duration or success probability of the task element, 4= an equipment task element where operator factors are not considered and the task cannot be failed, 5= not used, 6= a special type of branch task element where either a "COR" or "ERR" response is expected	7
CRIT(I,K)-	Criticality of the task element. C=critical, not C is not critical	8
END(I,K)-	Message processing segment ended by this task element, if any	10
IJF(I,K)-	The number of the task element which will follow this one if this task element is a failure	12-14
IJS(I,K)-	The number of the task element which will follow this one if this task element is a success	15-17
AVGTM(I,K)-	Task element mean performance time	20-29
SIGMA(I,K)-	Standard deviation of AVGTM(I,K)	30-39
AVPROB(I,K)-	Task element success probability, the probability that the following task will be IJS(I,K) and not IJF. Also the probability of message rejection when JTYPE(I,K)=1	40-49
UETYPE(I,K)-	Undetected error type T=transform, not T=all others	50
UEP(I,K)	Undetected error probability	51-56

Table A-9 shows the card formats and contents of card types 16, 17, and 18. Card type 16 determines whether or not new effectiveness component data (i.e., card type 17) will be read in or not. Card type 17 contains the correlations among effectiveness components, as well as the relative weight of each component in the computation of overall effectiveness (see Appendix C).

Card type 18 determines whether or not a new run should be set up. It thereby determines whether or not a card type 1 will be read, thus cycling through cards 1-17 again.

Table A-9

Input--Effectiveness Component Data

		Card Colum
Read or skip effectiveness components (card type 16)		
ISKIP-	If equal to 1 skip to read card type 18. If not equal to 1 read card type 17	1
Effectiveness components (card type 17)		
CC12-	Correlation between thoroughness and completeness	1-4
CC13-	Correlation between thoroughness and responsiveness	5-9
CC14-	Correlation between thoroughness and accuracy	10-14
CC23-	Correlation between completeness and responsiveness	15-19
CC24-	Correlation between completeness and accuracy	20-24
CC34-	Correlation between responsiveness and accuracy	25-29
W(1)-	Relative weight of thoroughness in computing overall effectiveness	30-34
W(2)-	Weight of completeness	35-39
W(3)-	Weight of responsiveness	40-44
W(4)-	Weight of accuracy	45-49
The weights must sum 1.0		
Repeat for new run (card type 18)		
IREP-	If equal to 1, read card type 1. If not equal to 1 terminate program	1

Glossary

Table A-10 presents a glossary of FORTRAN variable names. This glossary includes all variables except those already defined in Tables A-1 through A-9. Table A-10 is partitioned into dimensioned variables (i.e., variables which are actually a matrix of related variables) and nondimensioned variables.

Table A-10

Glossary of Principal FORTRAN Variable Names

Dimensioned Variables

Z(M)	Current time last worked
TW(IH,M)	Total hours worked in a shift
NOSUC(M)	Number of successes for man M
NOFAIL(M)	Number of failures for man M
EC(NEC)	Value of effectiveness component
PERF(M)	Performance of man M
AVAIL(M)	Availibility indicator for man M; 1=available;0=not available
IDI(IH,M)	Idle time for man M
INFOLS(CMSG)	Information loss for this message
PASP(M)	Permanent aspiration level (necessary because aspiration level may change within a given iteration)
INTRPT(M)	Set to 1 if this man has an interrupted message
MSGIRP(M)	Message number of interrupted message, this man
MESS(LA,J)	Messages; LA=1 total for hour; LA=2 to do this hour, in queue
STR(M)	Operator stress
OUT(MSG,J)	Outcome for this message C= Complete I= Interrupted R= Rejected Blank= Ready for processing if it has arrived
ISTKNT(1-5)	Weights used in computing operator stress based on message priority

Table A-10 (Cont.)

Nondimensioned Variables

MSGNO	Number of message being processed
NOMSGS	Number of messages arrived with priority greater than 1
IHMAX	Length of workday (hours)
MSG	Number of next message to be processed
ST	Start time for message processing
RY	Pseudo random number equiprobable in 0-1 internal
RD	Pseudo random (random deviate), mean=0, sigma=1
NSFT	Current iteration number
NSHIFT	Number of iterations to be performed
SF	Stress factor
TIME	Execution time of a task element
ZIF	Stress function for execution time
V	Basic execution time function
ZIH	IH minus 1 in seconds
TNUE	Total number of undetected errors in a messsage
SIF	Success or failure indicator
EFF	Efficiency
PAFA	Pace Adjustment Factor due to aspiration
PAFW	Pace Adjustment Factor due to work fatigue
PROB	Temporary for task element probability, adjusted
CMSG	Cumulative message number
KINKS	Number of messages interrupted from previous hour
AQT	Cummulative queue time for all messages in an hour
AHT	Cummulative handling time for all messages in an hour

Time Segments

SEGS(CMSG,1) TARIV(MSG,1)=time arrive in AO/G3 queue
SEGS(CMSG,2) Z(M) at PROC start=time of message start
SEGS(CMSG,3) Z(M) at PROC task elelement triggered=select format
SEGS(CMSG,4) TARIV(MSG,2)=time arrive IOD queue
SEGS(CMSG,5) Z(M) t-e triggered=IOD request format
SEGS(CMSG,6) Z(M) t-e triggered=IOD send message
SEGS(CMSG,7) Z(M) end of PROC triggered=IOD finished with message

Subroutines

Table A-11 presents the names and functions of each subroutine of the computer simulation program. The first routine -SIPS - is actually the main routine which then calls the subroutines as appropriate. This fragmentation of the program into many subroutines allows the program to be modified more easily.

Table A-11

Subroutine Names and Functions

Routine	Mnemonic	Function
SIPS	Simulation of Information Processing Systems	Main control program
SIMPAM	Simulation Parameters	Read simu ation parameters
PEOPLE	-	Read/generate personnel characteristics
HOUR	-	Read input given by hour
ERROR	-	Read error rate data
RESET	-	Prepare conditions for start of new shift
BAKLOG	backlog	Determine G-3 message queue characteristics
MESGEN	message generator	Generate message queues
MANDET	man determination	Selects a man and a message to simulate next
RESHR	reset for hour	Prepare conditions for new hour
ITSUM	iteration summary	Print results of simulating each iteration of a shift
RUNSUM	run summary	Print summary of ITER iterations and accumulative totals for summary of all shifts when changing option is utilized
PROC	processing	Simulation for a message
RAND	random numbers	Generate pseudo random no. 0-1
INPOA	inverse normal probability	Generate pseudo random no. normal distribution
FATIGU	fatigue	Calculate work fatigue
ASPIRE	aspiration	Calculate aspiration
POIS	POISSON	Random number from poisson distribution
DUMPY1	dump-one	Entry point to RUNSUM which provides dumping of message queue to disc file at end of a shift for each ITER iterations
DUMPY2	dump-two	Same as DUM (1 for "from-disc" case
CHAINIT	chain initialization	Entry point to RUNSUM which provides initialization of summation arrays for changing option
TOTIT	Totals	Entry point to RUNSUM which provides computation and display of summary data over all shifts for changing option

APPENDIX B

Interactive Model User's Manual

This manual presents the implementation of the experimenter and subject interface to the TOS model. The manual includes a program narrative, complete input and deck set-up instructions, variable lists, flow charts, and user's instructions. The manual is written with the assumption the reader is familiar with the original model developed by Applied Psychological Services, (Siegel, Wolf & Leahy, 1972) and its strenghtened version.

Program Narrative

The experimenter interface logic is contained in a subroutine called EXPER. EXPER is entered at the completion of a run if the experimenter option has been selected (EXIN=1). In EXPER, all displays are routed to the experimenter's screen.

First, the experimenter optionally views a summary of the simulation run just completed. He can then terminate the program, continue the program with input for the next run coming from the input files, or he can provide input parameters at his screen. If the experimenter selects the experimenter input option, he receives a display which names groups of input variables for which he can provide new values.

After he selects an input group, he views the current values of each of the input variables in that group. He replaces, on the screen, the current value he wants in effect for the next run. EXPER allows the user to verify the new input value and to make corrections, if necessary. Then the program returns to the step at which the input groups are displayed. The experimenter input cycle continues until the experimenter selects no input group. At this time control is returned to the simulation for another run with the modified input parameters.

As an independent subroutine, EXPER does not modify the simulation or affect any of the printed output which can be obtained after the experimenter terminates program execution.

The subject interface logic includes several strengthened TOS model subroutines. If the subject interface option has been selected (SBIN=1), the experimenter assigns subjects to the CDC 3300 display terminals before the simulation. If no one is assigned to a display terminal, then no subject interface will occur.

If at least one subject has been assigned to a display terminal, then the experimenter indicates which task analytic elements are to be performed by the subject and which elements are to be simulated by the model.

In the MESGEN subroutine, at the beginning of each hour, an action officer message quene is built. This quene is displayed to the experimenter and he indicates which of the messages are to be replaced by messages which were prepared beforehand. The messages prepared beforehand are coded on computer cards and entered into the simulation in the input subroutines.

In the PROC subroutine, the man and the messages being processed are considered for subject processing. The following conditions must be satisfied for the subject to perform:

- The task analytic element under consideration must have been assigned a value of "P" in the TASKPS array.
- The man processing the message must have been assigned a CRT number in the CONSOL array.
- The message being processed must have been assigned a prestored message number in the FMT array.

If all the conditions are satisfied, then the experimenter indicates on his display whether or not the subject is to perform. The SUBJEK subroutine monitors subject performance.

Two types of subject monitoring are permitted. In one case, the subject's performance is observed by the experimenter who signals the computer program when the subject begins and ends the assigned task analytic element. The computer program computes subject performance time and accepts from the experimenter the number of subject errors and a success/failure indicator for the task. These variables are processed by the program as though they resulted from the actual simulation and the simulation continues.

The second type of subject monitoring involves the subject entering a message at his terminal. A TOS format which is associated with the prestored message being processed is displayed at the subject's station. The subject enters his responses and signals the

computer program when he has completed his task. The computer program computes subject performance time and the number of incorrect responses. The experimenter enters the task success/failure indicator. Processing continues as in case described above.

Supporting Subroutines

WDISP is a FORTRAN coded subroutine which controls all input/output processing for the CRT displays. The CLOCK function is utilized to compute processing time for subject performance and also to terminate the program if no response is received from the experimenter within six minutes from the time that he receives a new display. WDISP also facilitates the hardcopy option, dumping screen images to the output file for later printing.

DSOUT is a FORTRAN coded subroutine which writes print line images to the output file on disc. Up to 20 line images can be written to the disc in a single call to DSOUT. DSOUT utilizes the RANWRITE subroutine for background processing.

DSIN is a FORTRAN coded subroutine that reads 80 character records (card images) from the disc input file. DSIN itilizes the RANREAD subroutine for background processing.

Computer Program Variables

The following dimensioned variables are introduced by the experimenter/subject interface logic.

CONSOL (6)	CRT cumber of each man who is to be replaced by a subject.
EXASP (6)	Aspiration at end of run for each man.
EXTMP (6)	Average time to process a message (in seconds) for each man.
EXASPH (12,6)	Aspiration at end of each hour for each man.
EXTPM (12,6)	Average time to process a message for each hour for each man.
EXPR (2)	First element is average completion time per message for a run; second element is effectiveness.
FTN (50)	Prestored message number for each message to be processed by a subject in the simulation.
IBUFF (250)	Buffer containing space for 1000 characters to be displayed on a CRT or to be read from a CRT.
LL (20)	A utility array used in several subroutines.
RMESS (3,15) RMESS (1,15)	Pointer to first input record (on disc) for corresponding [illegible]OS format for each prestored message.
RMESS (3,15)	Pointer to second input record (on disc) for each prestored message.
RMESS (2,15)	The number of responses for each prestored message.

The following variables are introduced by the experimenter/subject interface logic.

EXIN	Experimenter interface indicator input by user. If 1, then interface will be exercised; if 0, no.
IGTO	Control indicator set by WDISP and EXPER subroutines. If 1, then control is to return to normal input processing after experimenter interface; if 2, then experimenter has provided input for next run; if 3, then run is to be terminated because experimenter has chosen to end experiment or because experimenter has failed to respond to a message on the CRT within six minutes.
IBLKI	Input file record pointer. Integer value points to current input record (one record is one card in the input data deck).
IBLKO	Output file record pointer. Integer points to current output record (one record is one print line).
ISCRN	Screen number for the experimenter. Integer value from 1 to 6 provided input data.
KKK	Indicator for WDISP subroutine. Initialized at 0 and set to 1 at first entry to WDISP. If 1, subroutine calls CLOCK subroutine to test response time of experimenter; if 0, the WAIT subroutine is called to initialize interrupt processing by the operating system.
TASKPS (4,20)	Indicator for each task analysis element. If "P", the task element is to be performed by subject; if "S", the task element is to be simulated.
IOUTJB (680)	Buffer to hold print line images to be written to output file and card images read from input line.
IFORMZ (300)	Array to hold TOS formats to be displayed on CRT. Capacity 15 cards for each format.

RM2 (35)	Array of 35 characters to hold a message response from the subject.
RM1 (35)	Array of 35 characters to hold correct response for a prestored message.
LLL	Indicator for OVRLY3 subroutine. If 1, RESET and BACKLOG subroutines are called upon entry to OVRLY3; of 2, ITSUM and BACKLOG are called if the run is not complete; if 2 and the run is complete, then ITSUM and RUNSUM are called; if 3, RUNSUM is called.
MENSP	Counter for a number of men to be replaced by subjects in the simulation.
NCC	Indicator used in OVRLY1 and input subroutines. If '*,' then data are read from input file; if not '*,' then NCC will be total number of messages processed for a run. In the latter case, NCC is displayed for the experimenter and indicates that no additional data are to be read from the input file.
SBIN	Subject interface indicator input by user. If 1, then subject interface logic will be exercised; if 0, no.
NRD	Number of responses for prestored message being processed.
NWRG	Counter for number of incorrect responses from subject.

Desk Arrangement

The Card to Disc Program reads the input data for the interactive mode and places the data into a disc file. The disc file created is the input file for the interactive program. The card-to-disc program can be executed any time before the simulation is run. The desk organization is:

$^{7}_{9}$JOB, CS-A-18, *NAME*, 112, NP, ND

$^{7}_{9}$FET, APS-SIM, APS-SIM-SCD-INP, 256,,,

$^{7}_{9}$OPEN, 2

$^{7}_{9}$EQUIP, 1=60

$^{7}_{9}$LOAD

OBJECT DECKS FOR CARD-TO-DISC
AND RANREAD/RANWRITE PROGRAMS

$^{7}_{9}$RUN

.
.
.
INPUT DATA CARDS
.
.
.

77 EOF

88(CARD)

Output from the execution of this program is a listing of the input data cards and the input data file on disc for use by TOSS.

This interactive program includes the original TOSS program with the experimenter and subject interface logic incorporated. The program is executed in background mode. The desk setup follows:

$^{7}_{9}$BACK, ND, CS-A-18, *NAME*, 115

$^{7}_{9}$FET, TEMP, SCRATCH1,,,

$^{7}_{9}$MODIFY,,, NEWFET

$^{7}_{9}$FET, TEMP, SCRATCH1, 256

$^{7}_{9}$OPEN, 25

$^{7}_{9}$FET, APS-SIM, APS-SIM-BCD-INP, 256,,,

$^{7}_{9}$OPEN, 1

$^{7}_{9}$FET, APS-SIM, AFS-SIM-BCD-OUT, 256,,,

$^{7}_{9}$OPEN, 2

$^{7}_{9}$LOAD

AQ

OBJECT DECKS FOR
DEMON, WDISP, DSOUT, DSINP AND
SYSTEMS SUBROUTINES FOR OVERLAY,
CRT, CRT COMMUNICATIONS, RANDOM
I/O, AND CLOCK FUNCTIONS

B25,1
OBJECT DECKS FOR
OVRY1, SIMPAM, PEOPLE, HOUR,
ERROR

B25,2 OBJECT DECKS FOR
OVRLY2,ASPIRE, POIS AND RANDOM
NUMBER GENERATOR SUBROUTINES

C25,1 OBJECT DECKS FOR
MESGEN SUBROUTINES

C25,2 OBJECT DECKS FOR
MANDET, PROC, SUBJEK SUBROUTINES

C25,3 OBJECT DECK FOR
RESHR SUBROUTINE

B25,3
OBJECT DECKS FOR
OVRLY3, RESET, BACKLOG, ITSUM,
RUNSUM AND RANDOM NUMBER GEN-
ERATOR SUBROUTINES

B25,4 OBJECT DECK FOR
EXPER SUBROUTINE

7 RUN
9

77 (EOF CARD)
88

NOTES:

A indicates a multi-punched column: +,0,7,9
B indicates a multi-punched column: +,0,3,7,9
C indicates a multi-punched column: +,0,2,7,9

The Disc to Printer Program reads and prints the output file generated by the interactive program. The program is executed in foreground mode and can be run any time following completion of a simulation run in the interactive mode to obtain the results of that simulation.

```
7
9 JOB, CS-A-18, *NAME*, 112, NP, ND

7
9 FET, APS-SIM, APS-SIM-BCD-OUT, 256,,,

7
9 OPEN, 2

7
9 LOAD

          OBJECT DECKS FOR
          DISC-TO-PRINTER AND
          RANREAD PROGRAMS

7
9 RUN

77
88 (EOF CARD)
```

Output from the execution of this program is a list of the interactive computer program output.

Input Data

This section presents the formats required for preparing input data for the TOSS computer program with experimenter/subject interface. For each input data field on a computer card, the appropriate card columns (cc) and FORTRAN format (FF) are given. An "I" format requires that the input value be right justified in the field with an "f" format requires right justification only if no decimal point is included; it is desired to override the position of the point defined in the format; an "A" format indicates that characters are entered into arrays without conversion.

CARD 1 (prestored message data)

cc: 1-2	FF:	I2	Number of TOS formats in input data
3-4		I2	Number of prestored messages in input data

CARD 2 (number of cards to describe TOS format)

cc: 1-2	FF:	I2	Value must not exceed 15

CARD 3 (TOS formats)

The format is prepared in the same manner as a standard FORTRAN format atatement. The definition of the data to be displayed must be delimited by left and right parentheses, respectively. Fields within the parentheses must be separated by commas. Two types of fields are permitted:

- Spaces- to insert *m* spaces in the display enter *mx*.
- Character string - to insert a string of *m* characters, enter the character string immediately preceded by *mH*. For example, to produce the string "A TEST", enter *6HA TEST*.

The sum of the characters presented in the format cannot exceed 1000. The screen is formatted into 20 lines of 50 characters each. CARD 2 and CARD 3 are repeated, in sequence, for each TOS format desired.

CARD 4 (prestored message)

cc; 1-2	FF	I2	Sequential order of the TOS format (input in CARD 2, CARD 3) associated with this message
3-4		I2	Number of responses for this message

CARD 5 (message responses)

cc: 1-3	FF:	I3	Number of characters, from the screen origin (character 1, line 1), to skip before message response
4-5		I2	Number of characters in response
6-40		35A1	Character string representing correct message response

CARD 5 is repeated in sequence, for each response in the message.

CARD 4 and CARD 5 are repeated for each prestored message desired.

CARD 6 (mission title)

cc: 1-72	FF:	18A4	72 character mission title

CARD 7 (simulation parameters)

cc: 1-3	FF:	I3	NSHIFT--number of iterations before mission summary is prepared
4-5		I2	IHMAX--number of hours per shift
6		I1	MEN(1)--number of type 1 operators (action officers)
7		I1	MEN(2)--number of type 2 operators (IOD operators)

cc: 8-9	FF:	2X	not used
10		I1	ORO(1)--if 1, print input data
11		I1	ORO(2)-- print hourly message queue
12		I1	not used
13		I1	ORO(4)--if 1, print task element detail
14		I1	ORO(5)--if 1, print message processing
15		I1	ORO(6)--if 1, print hour and iteration summary
16-18		3X	not used
19-20		I2	IDAY--day number of mission simulated
21-22		I2	BKLG--number of messages in AO/G3 inbox at beginning of shift
23-24		2X	not used
25-29		F5.3	PUL--probability of a nonimportant undetected error in central computer
30-34		F5.3	PUS--probability of a significant error in the central computer
35-39		F5.3	SRTA--system response time to an inquiry
40-44		F5.3	SRTS--standard deviation of SRTA
45		I1	IATA(1,1)--sequential order of task analysis to be used for operator type 1 processing a message type 1
46		I1	IATA(1,2)--for message type 2
47		I1	IATA(1,3)--for message type 3
48		I1	IATA(1,4)--for message type 4
49		I1	IATA(1,5)--for message type 5
50		I1	IATA(1,6)--for message type 6

cc: 51	FF:	I1	IATA(1,7)--for message type 7
52		I1	IATA(1,8)--for message type 8
53		I1	IATA(2,1)--operator type 2/message type 1
54		I1	IATA(2,2)--operator type 2/message type 2
55		I1	IATA(2,3)--operator type 2/message type 3
56		I1	IATA(2,4)--operator type 2/message type 4
57		I1	IATA(2,5)--operator type 2/message type 5
58		I1	IATA(2,6)--operator type 2/message type 6
59		I1	IATA(2,7)--operator type 2/message type 7
60		I1	IATA(2,8)--operator type 2/message type 8
61-63		I3	NTE--total number of task elements in all task analysis
64-70		A8	Y--eight digit positive odd octal number used to initialize random number generator
72		I1	EXIN--if 1, experimenter interface affected
73		I1	ISCRN--screen number for experimenter
74		I1	HARD--hard copy option for CRT displays: 0-none 1-for viewers' responses 2-for displays to viewers 3-both 1 and 2
75		I1	SBIN--if 1, subject interface effected

CARD 8 (option for operator parameters)

cc:	1	FF:	I1	ISKIP--if 1, then CARD 9 and CARD 10 will not be present. This option can be used in a multiple-run situation when values of parameters for the current run are to remain as they were for the previous run

CARD 9 (operator names)

cc:	1-4	FF:	A4	NAME 1--name of operator 1
	5-8		A4	NAME 2--name of operator 2
	.		.	.
	.		.	.
	.		.	.
	.		.	.
				(up to 6 operators can be named)

CARD 10 (operator parameters)

cc:	1	FF:	I1	M--man number (from 1 to 6)
	2-4		3X	not used
	5-9		F5.3	F(M)--speed factor for this man 1.0 is average; F(M)<1.0 indicates faster than average man; F(M)>1.0 indicates a slower than average man
	10-14		F5.3	PREC(M)--precision factor for this man 1.0 is average; PREC(M)=.8 indicates very high precision; PREC(M)=1.2 indicates a very low precision. The 1.2 value is not to be used.
	15-19		F5.0	STRM(M)--stress threshold for this man. The number of priority messages in the backlog for this man which will produce a maximum effort.
	20-24		F5.3	ASP(M)--initial aspiration level for this man. ASP(M)=1.0 is the highest possible aspiration level.

CARD 10 is repeated for each man (up to 6)

CARD 11 (skip option for hour parameters)

cc:	1	FF:	I1	ISKIP--if 1, then CARD 12 and CARD 13 will not be present (see CARD 8)

CARD 12 (names of message types)

cc:	1-4	FF:	A4	NMTYP(1)--name of message type 1
	5-8		A4	NMTYP(2)--name of message type 2
	.		.	.
	.		.	.
	.		.	.
	.		.	.
	.		.	.
				(up to 7 message types can be named)

CARD 13 (hour parameters)

cc:	1-2	FF:	I2	IH--hour number (from 1 to 12)
	3-4		I2	IGP(IH)--number of messages arriving in AO/G3's in box in last 15 minutes of this hour
	5-6		I2	IGR(IH)--number of messages arriving in AO/G3's inbox randomly throughout this hour
	7-8		I2	IUR(IH)--not used
	9		1X	not used
	10-14		F5.0	FRET(1,IH)--cumulative proportional occourance of message type 1:ADD
	15-19		F5.0	FRET(2,IH)--type 2:CHANGE
	20-24		F5.0	FRET(3,IH)--type 3:DELETE
	25-29		F5.0	FRET(4,IH)--type 4:QUERY
	30-34		F5.0	FRET(5,IH)--type 5:RELAY
	35-39		F5.0	FRET(6,IH)--type 6:SPR
	40-44		F5.0	FRET(7,IH)--type 7:SRI

cc:45-49	FF:	F5.0	FREP(1,IH)--cumulative proportional occourence of messages of priority type 1:ROUTINE
50-54		F5.0	FREP(2,IH)--priority type 2:PRIORITY
55-59		F5.0	FREP(3,IH)--priority type 3:OPERATIONAL IMMEDIATE
60-64		F5.0	FREP(4,IH)--priority type 4:FLASH
65-69		F5.0	FREP(5,IH)--priority type 5:PRESIDENTIAL INTERRUPT
70-74		F5.0	FRER(IH)--frequency of arrival of routine messages this hour
75-79		F5.0	FREQ(IH)--frequency of arrival of other than routine messages this hour

CARD 13 is repeated for IHMAX hours

CARD 14 (skip option for error data)

cc: 1	FF:	I1	ISKIP--if 1, then CARD 15 will not be present (see CARD 8)

CARD 15 (error data)

cc: 1	FF:	I1	IE--indicator for error type: 1=COMMISSION 2= ABBREVIATION, TYPOGRAPHICAL OR SPACING 3= OMMISSION, 4= OTHER
2-9		F8.2	ER(IE,1)--error rate per 100 characters for message type 1
10-17		F8.2	ER(IE,2)--for message type 2
18-25		F8.2	ER(IE,3)--for message type 3
26-33		F8.2	ER(IE,4)--for message type 4
34-41		F8.2	ER(IE,5)--for message type 5
42-49		F8.2	ER(IE,6)--for message type 6

cc:50-67	FF:	F8.2	ER(IE,7)--for message type 7
58-65		8X	not used
66-72		F7.2	EPRG--percentage of G3/AO errors which produce error routines
73-79		F7.2	ERPI--percentage of UIOD operator errors which produce error routines

CARD 15 is repeated 4 times, once for each error type

CARD 16 (skip option for message length data)

cc: 1	FF:	I1	ISKIP--if 1, then CARD 17 and CARD 18 will not be present (see CARD 8)

CARD 17 (message length data)

cc: 1-10	FF:	F10.2	INC(1)--number of characters in transformed message type 1
11-20		F10.2	INC(2)--for message type 2
21-30		F10.2	INC(3)--for message type 3
31-40		F10.2	INC(4)--for message type 4
42-50		F10.2	INC(5)--for message type 5
51-60		F10.2	INC(6)--for message type 6
61-70		F10.2	INC(7)--for message type 7

CARD 18 (message length--standard deviations)

cc: 1-10	FF:	F10.2	INS(1)--standard deviation of INC(1)
11-20		F10.2	INS(2)--standard deviation for INC(2)
21-30		F10.2	INS(3)--standard deviation for INC(3)
31-40		F10.2	INS(4)--standard deviation for INC(4)

cc:	41-50	FF: F10.2	INS(5)--standard deviation for INC(5)
	51-60	F10.2	INS(6)--standard deviation for INC(6)
	61-70	F10.2	INS(7)--standard deviation for INC(7)

CARD 19 (skip option for task analysis data)

cc:	1	FF: I1	ISKIP--if 1, then CARD 20 will not be present (see CARD 8)

CARD 20 (task analysis data)

cc:	1-2	FF: I2	K--task analysis number
	3-5	I3	I--task element within this analysis
	6	1X	not used
	7	A1	JTYPE(I,K)--task element type:1=task element which may be rejected with probability specified by AVPROB(I,K); 2=task element in which number of characters for this message type will be multiplied by statistically determined mean time to produce transformation time for message; 3=decision task element in which operator factors such as speed, precision, and stress level are not allowed to affect duration of task element; 4=an equipment task element for which operator factors are ignored and task element can not be failed; (5=not used); 6=special type of branch task element in which either a "COR" or "ERR" response is expected.
	8	A1	CRIT(I,K)--criticality indicator for task element: "C" for critical, otherwise not critical
	9	1X	not used
	10	A1	END(I,K)--number of message processing segment ended by this task element. Leave blank, if none.
	11	1X	not used

cc:	12	FF: I3	IJF(I,K)--number of the task element within this task analysis which will follow this one if this element is failed
	15-17	I3	IJS(I,K)--number of task element within which this analysis which will follow this one if this task element is a success
	18-19	2X	not used
	20-19	F10.0	ACGTM(I,K)--mean performance time for this task element
	30-29	F10.0	SIGMA(I,K)--standard deviation for AUGTM(I,K)
	40-49	F10.0	AVPROB(I,K)--probability of success for this task element. If JTYPE(I,K)=1, then AVPROB (I,K) is probability of message rejection
	50	A1	UETYPE(I,K)undetected type for this task element: "T" for transform, not "T" for all others
	51-56	F6.3	UEP(I,K)--probability for undetected error for this task element

CARD 20 is repeated NTE times (CARD 7, columns 61-63)-- once for each element

CARD 21 (skip option for effectiveness components)

cc:	1	FF: I1	ISKIP--if 1, CARD 22 will not be present (see CARD 8)

CARD 22 (effectiveness components)

cc:	1-5	FF: F5.3	CC12--correlation between thoroughness and completeness
	6-10	F5.3	CC13--correlation between thoroughness and responsiveness
	11-15	F5.3	CC14--correlation between thoroughness and accuracy

cc:16-20	FF: F5.3	CC23--correlation between completeness and responsiveness
21-25	F5.3	CC24--correlation between completeness and accuracy
26-30	F5.3	CC34--correlation between responsiveness and accuracy
31-35	F5.3	W(1)--relative weight of thoroughness in computing overall effectiveness
36-40	F5.3	W(2)--relative weight of completeness
41-45	F5.3	W(3)--relative weight of responsiveness
46-50	F5.3	W(4)--relative weight of accuracy

CARD 23 (repeat option)

cc: 1	FF: I1	IREP--if 1, another set of input data cards follow; otherwise, terminate computer program

Operating Instructions

Input data are prepared and punched on computer cards. These cards are inserted into the CARD-TO-DISC program deck and the disc pack reserved for the interactive model is mounted on an available disc drive. The program is executed in the foreground mode, resulting in a list of the data (which may be checked for errors) and writing of the input file to the disc. The input file will remain on disc until the next execution of CARD-TO-DISC.

The interactive program is executed in background mode so that the card reader and printer are not available to the program. The disc pack reserved for the interactive model must be mounted during program execution.

A list of the results of the most recent simulation run is obtained by executing the DISC-TO-PRINTER program in foreground mode. Again, the disc pack must be mounted when DISC-TO-PRINTER is executed. Information Displays are routed to the experimenter's screen at varous times during and following a simulation run. For each display, execution of the computer program will not resume until the experimenter depresses the SEND key on the keyboard.

In displays requiring experimenter input, some care is required in depressing the SEND key. Many of the numerical fields displayed are juxtapositioned. Thus, if the experimenter replaces a numerical value in a field and causes a SEND character to be placed in the first position following the field, the SEND character is actually placed in the second field. In most cases, this sequence will cause the value of the field containing the SEND character to be interpreted as zero. An easy way to avoid this problem is to depress the RESET key immediately prior to depressing the SEND key.

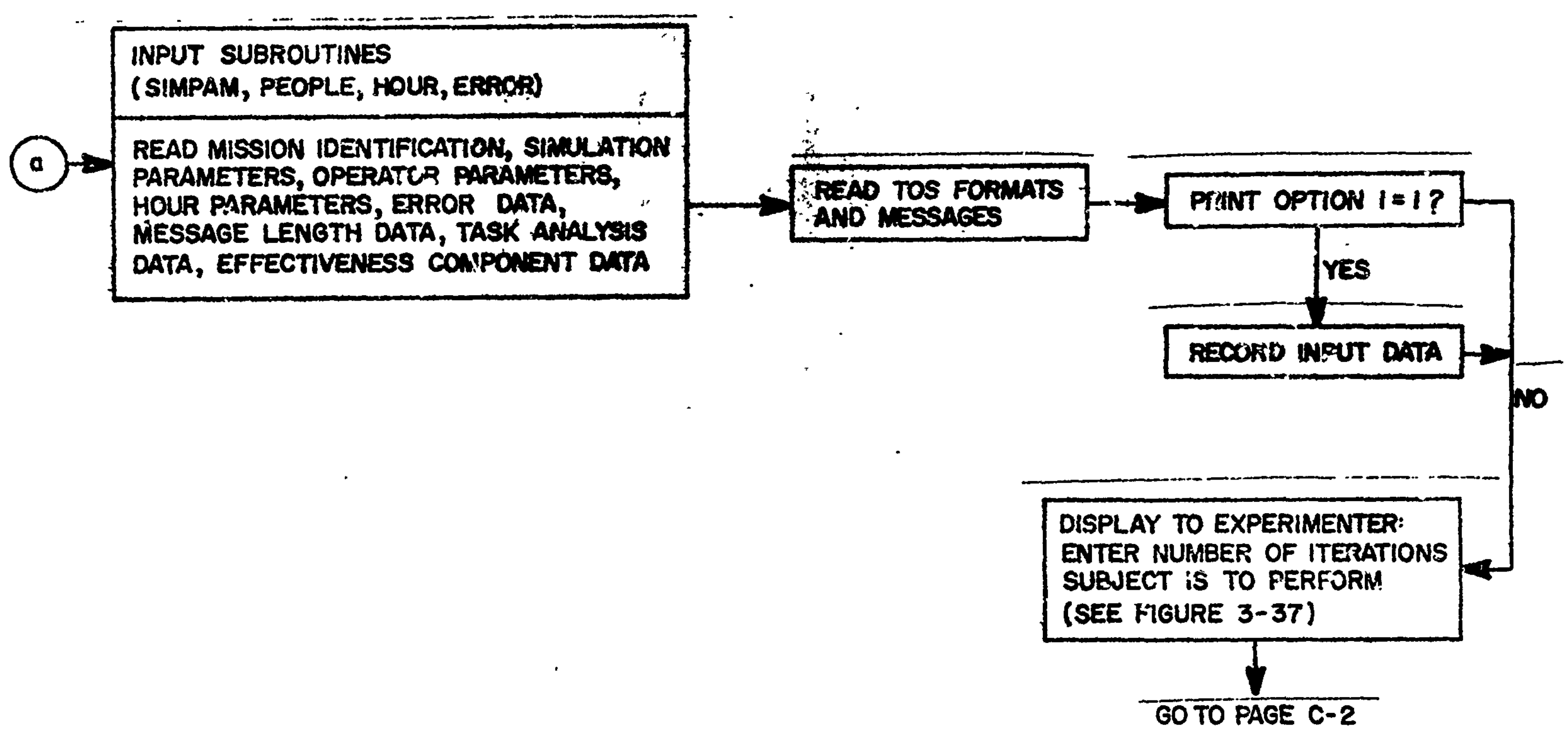
If the subject interface option is in effect, communication is established with the subject when he is to enter message reponses on his screen. First, he receives a message announcing that a TOS format will be displayed on his screen. When he is ready to input his responses, he depresses the SEND key. The computer program starts to time subject response time when it displays the TOS format. When the subject has completed entering his message, he again depresses the SEND key to signal the computer to compute his performance time As with the experimenter, any time the subject receives an information display (his incorrect reponses, for example), he must depress SEND before the computer program will resume execution.

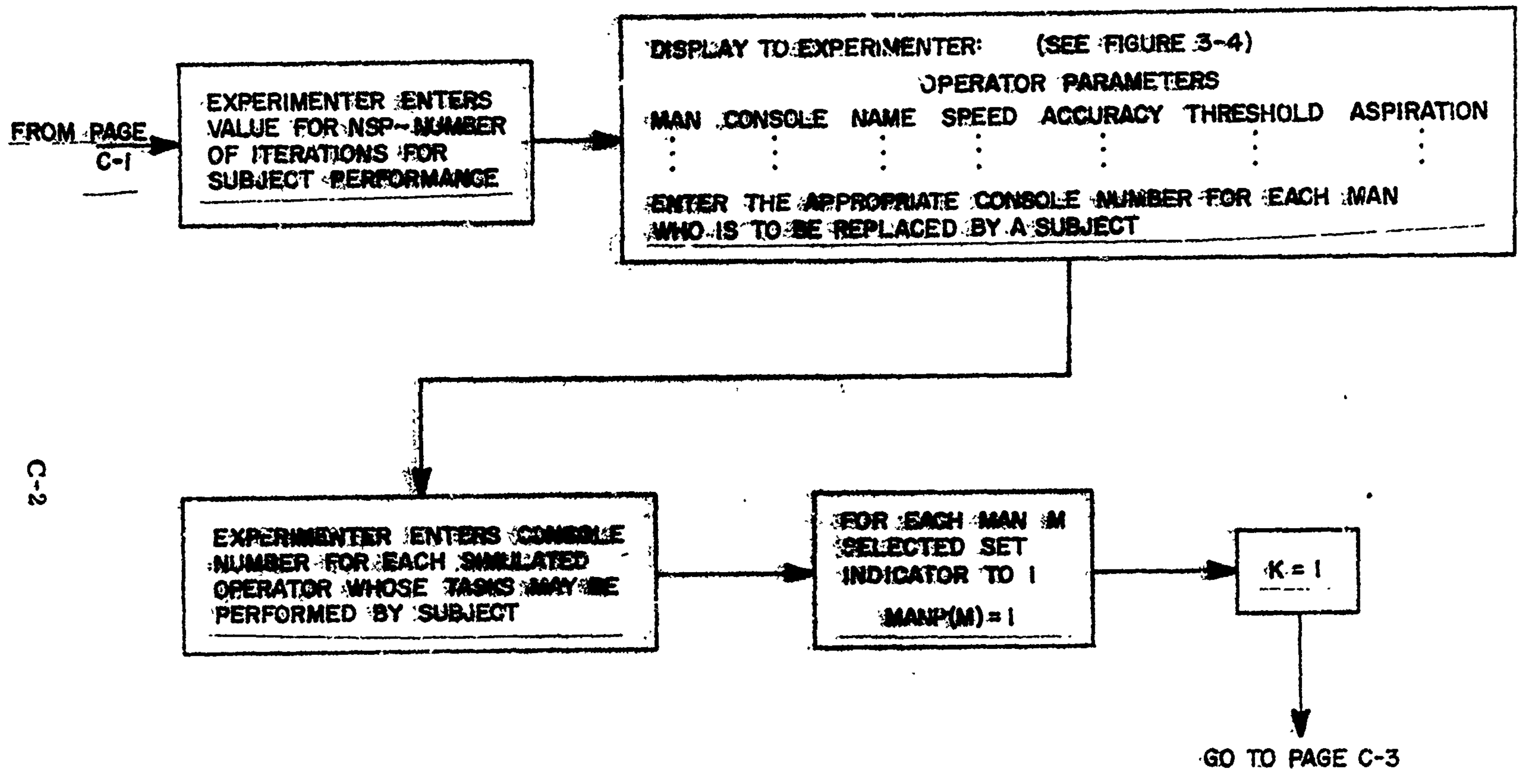
APPENDIX C

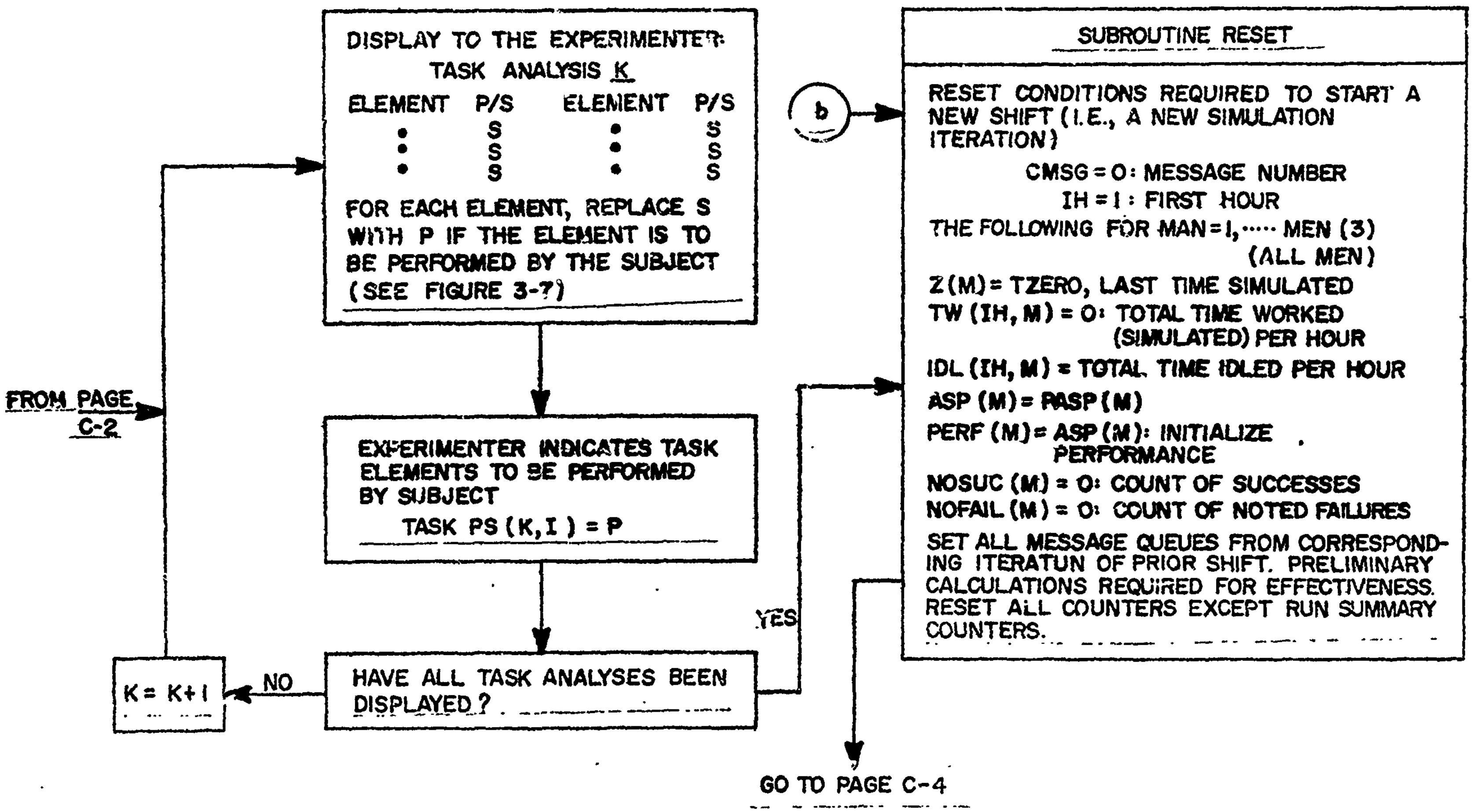
Main Sequence Logic Flow for Interactive Model

APPENDIX C

MAIN SEQUENCE LOGIC FLOW FOR TOS INTERACTIVE MODEL




FROM PAGE C-1
EXPERIMENTER ENTERS VALUE FOR NSP--NUMBER OF ITERATIONS FOR SUBJECT PERFORMANCE
DISPLAY TO EXPERIMENTER: (SEE FIGURE 3-4)
OPERATOR PARAMETERS
MAN CONSOLE NAME SPEED ACCURACY THRESHOLD ASPIRATION
ENTER THE APPROPRIATE CONSOLE NUMBER FOR EACH MAN WHO IS TO BE REPLACED BY A SUBJECT
EXPERIMENTER ENTERS CONSOLE NUMBER FOR EACH SIMULATED OPERATOR WHOSE TASKS MAY BE PERFORMED BY SUBJECT
FOR EACH MAN M SELECTED SET INDICATOR TO 1
MANP(M) = 1
K = 1
GO TO PAGE C-3



FROM PAGE C-2
DISPLAY TO THE EXPERIMENTER: TASK ANALYSIS K
ELEMENT P/S ELEMENT P/S
S S
S S
S S
FOR EACH ELEMENT, REPLACE S WITH P IF THE ELEMENT IS TO BE PERFORMED BY THE SUBJECT (SEE FIGURE 3-7)
EXPERIMENTER INDICATES TASK ELEMENTS TO BE PERFORMED BY SUBJECT
TASK PS (K,I) = P
HAVE ALL TASK ANALYSES BEEN DISPLAYED?
NO
K = K+1
YES
b
SUBROUTINE RESET
RESET CONDITIONS REQUIRED TO START A NEW SHIFT (I.E., A NEW SIMULATION ITERATION)
CMSG = O: MESSAGE NUMBER
IH = I: FIRST HOUR
THE FOLLOWING FOR MAN = I, ····· MEN (3) (ALL MEN)
Z(M) = TZERO, LAST TIME SIMULATED
TW (IH, M) = O: TOTAL TIME WORKED (SIMULATED) PER HOUR
IDL (IH, M) = TOTAL TIME IDLED PER HOUR
ASP (M) = RASP (M)
PERF (M) = ASP (M): INITIALIZE PERFORMANCE
NOSUC (M) = O: COUNT OF SUCCESSES
NOFAIL (M) = O: COUNT OF NOTED FAILURES
SET ALL MESSAGE QUEUES FROM CORRESPONDING ITERATUN OF PRIOR SHIFT. PRELIMINARY CALCULATIONS REQUIRED FOR EFFECTIVENESS. RESET ALL COUNTERS EXCEPT RUN SUMMARY COUNTERS.
GO TO PAGE C-4

FROM PAGE C-3

ENTER MESSAGE GENERATION SUBROUTINE FOR G-3 (BAKLOG)

GENERATE MESSAGE BACKLOG FOR G-3, FOR THOSE MESSAGES IN THE G-3 BACKLOG QUEUE.

INPUT TO SUBROUTINE: BKLG

OUTPUT FROM SUBROUTINE FOR EACH MESSAGE:

CMSG	CUMULATIVE MESSAGE NO.
PRIOR (MSG,J)	PRIORITY CODE
TYPE (MSG,J)	TYPE OF MESSAGE
LENTH (MSG,J)	NO. CHARACTERS
TARIV (MSG,J)	TIME OF ARRIVAL

IF ICHAIN>1, RETRIEVE MESSAGE QUEUE FROM END OF LAST SHIFT AND ENTER MESSAGES WHICH WERE INTERRUPTED OR INCOMPLETE INTO MESSAGE BACKLOG FOR A-3 AND IOD RESPECTIVELY.

DISPLAY MESSAGE CORRESPONDENCE BETWEEN SHIFTS IF ORO(2)=1.

IF ICHAIN ≤ 1, PROCEED

C

SUBROUTINE RESHR

RESET CONDITIONS FOR START OF THE SIMULATION OF THE NEXT HOUR.

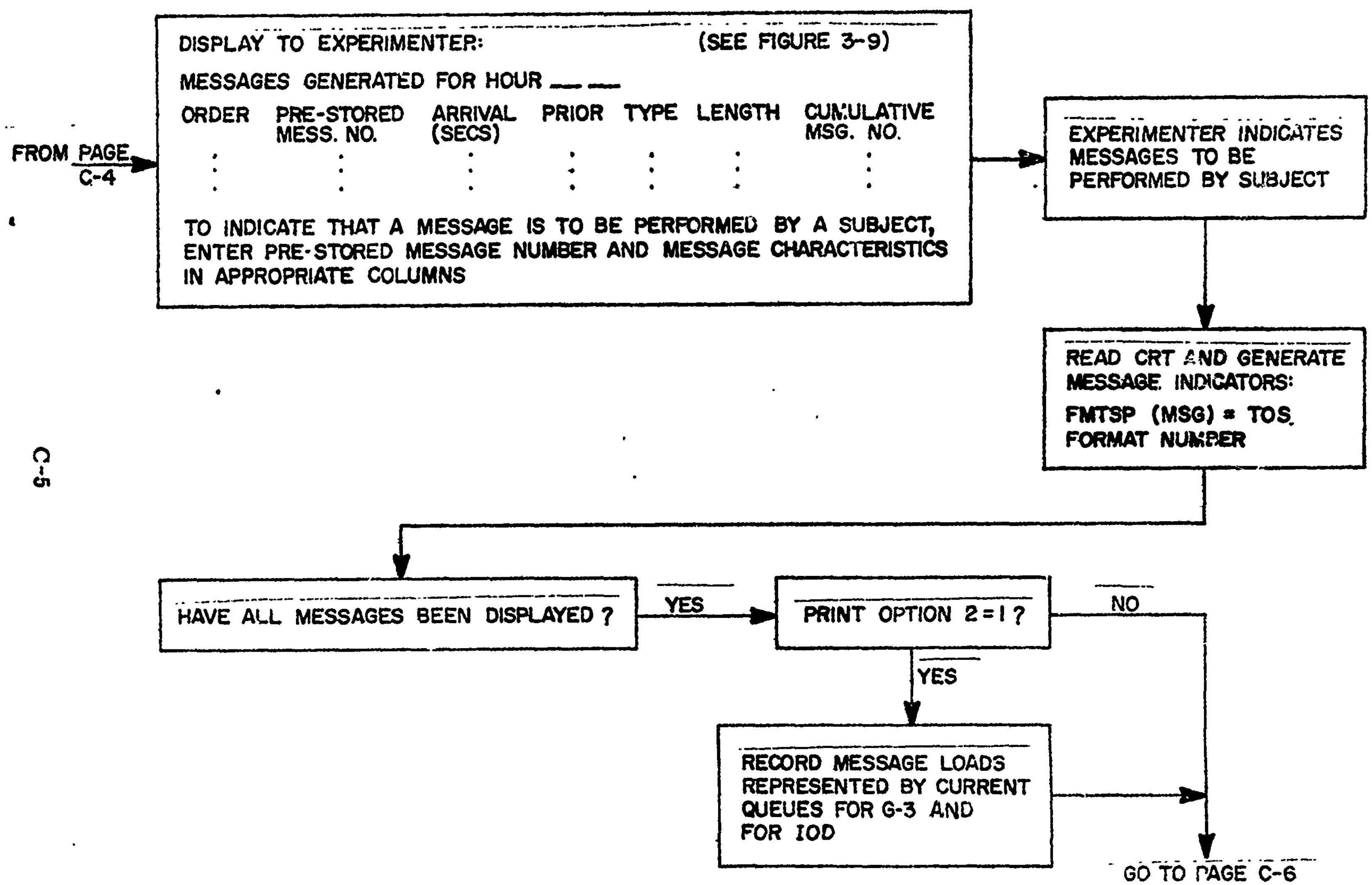
FOR ALL MAN = 1, 2,-----MEN(3)

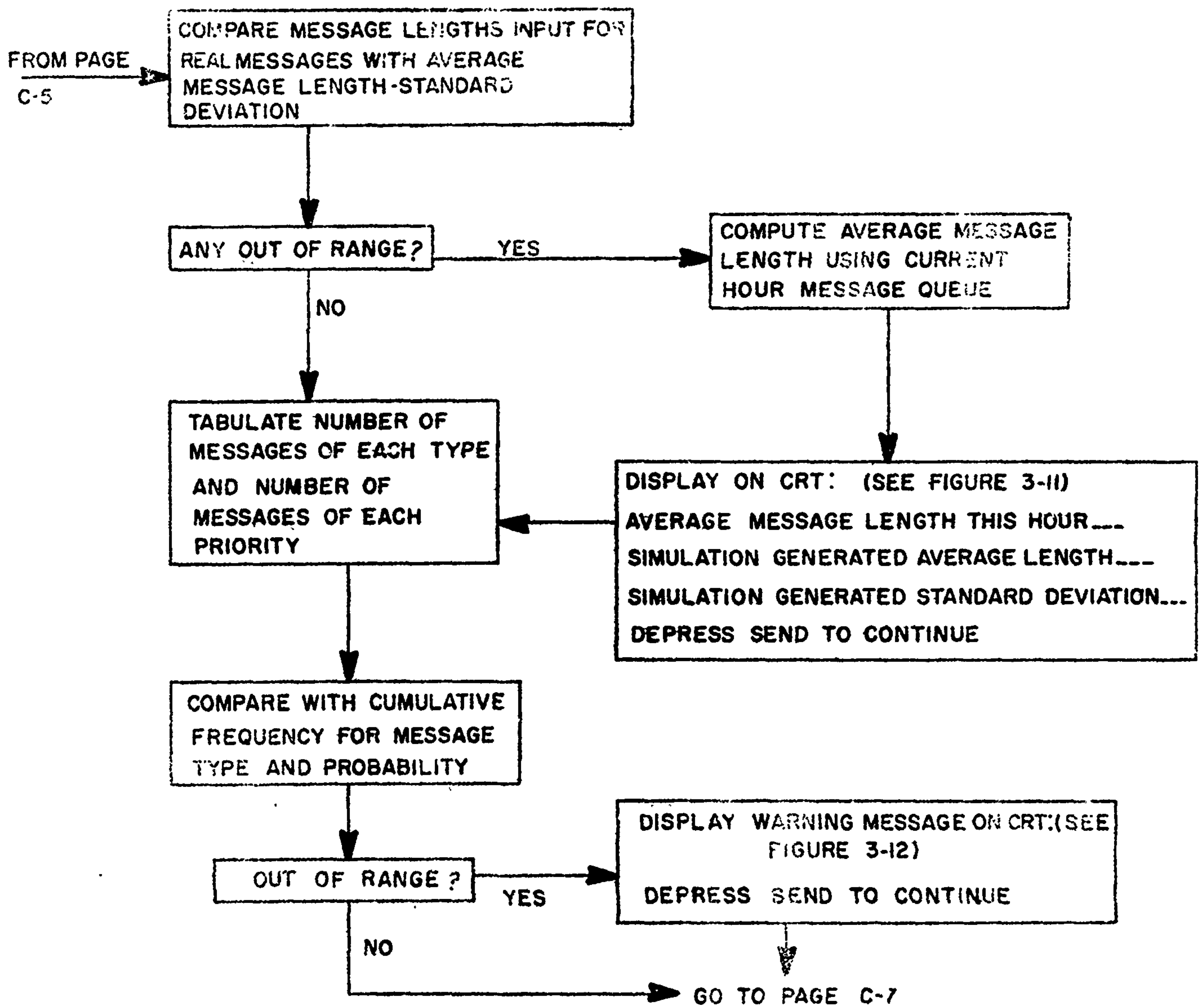
AVAIL (M) = 1 ALL MEN AVAILABLE

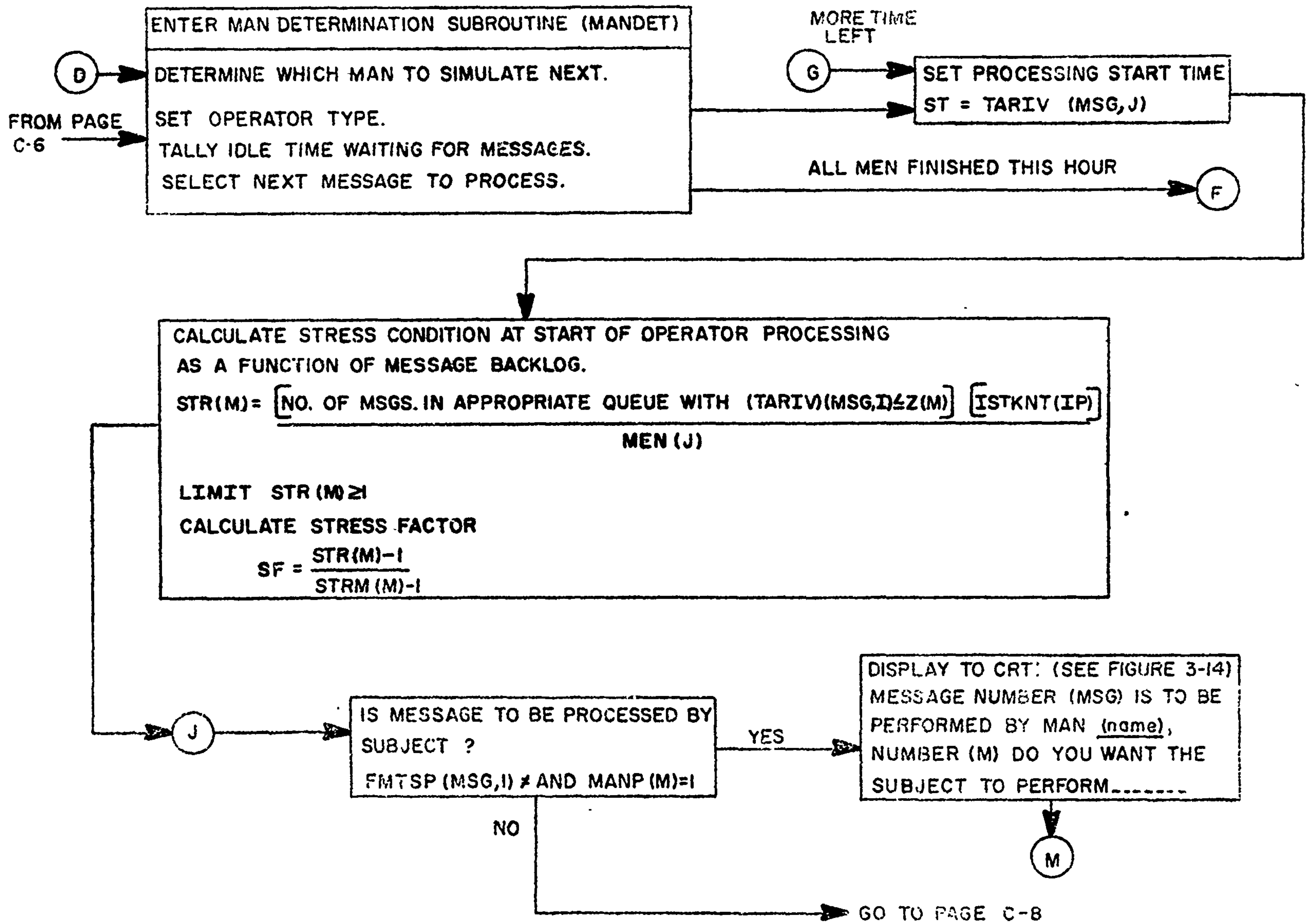
KINKS = NO. OF MESSAGES INTERRUPTED FROM PREVIOUS HOUR, IF ANY.

SORT/MERGE ALL MESSAGES IN IOD CURRENT AND BACKLOG QUEUES IN ORDER BY TIME OF ARRIVAL

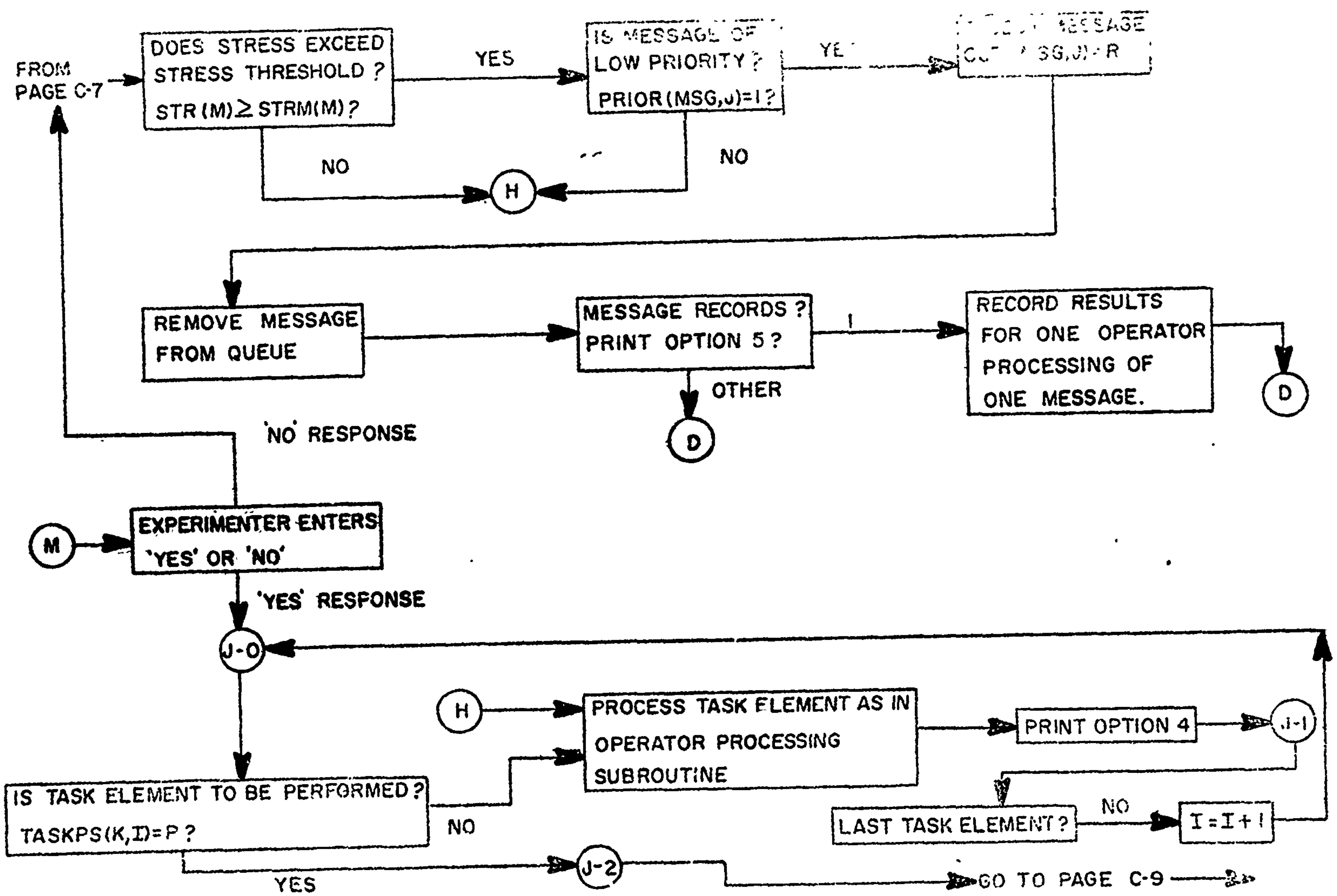
GO TO PAGE C-5

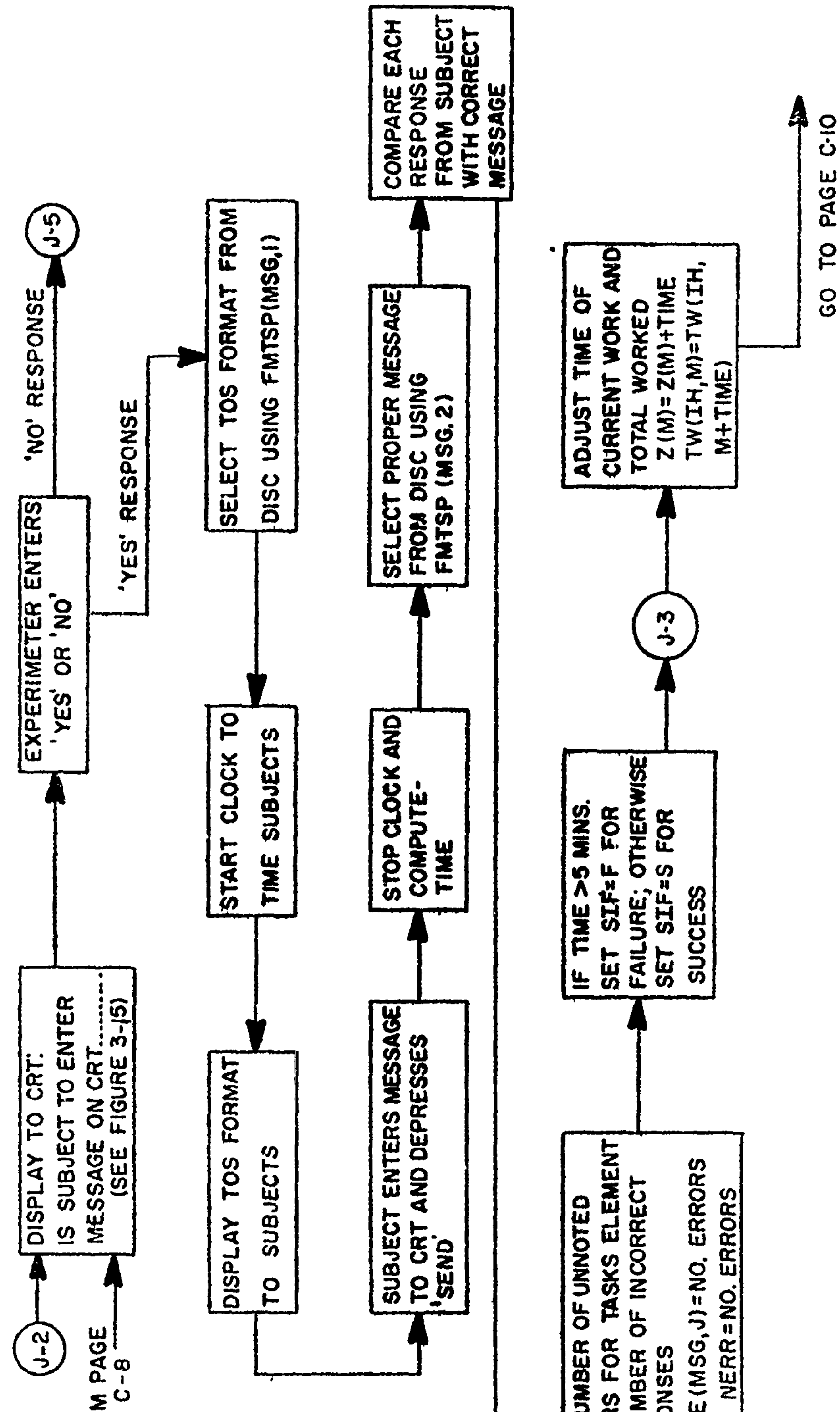

FROM PAGE C-4
DISPLAY TO EXPERIMENTER: (SEE FIGURE 3-9)
MESSAGES GENERATED FOR HOUR ___
ORDER PRE-STORED MESS. NO. ARRIVAL (SECS) PRIOR TYPE LENGTH CUMULATIVE MSG. NO.
TO INDICATE THAT A MESSAGE IS TO BE PERFORMED BY A SUBJECT, ENTER PRE-STORED MESSAGE NUMBER AND MESSAGE CHARACTERISTICS IN APPROPRIATE COLUMNS
EXPERIMENTER INDICATES MESSAGES TO BE PERFORMED BY SUBJECT
READ CRT AND GENERATE MESSAGE INDICATORS:
FMTSP (MSG) = TOS, FORMAT NUMBER
HAVE ALL MESSAGES BEEN DISPLAYED ?
YES
PRINT OPTION 2=1 ?
NO
YES
RECORD MESSAGE LOADS REPRESENTED BY CURRENT QUEUES FOR G-3 AND FOR IOD
GO TO PAGE C-6


FROM PAGE C-5
COMPARE MESSAGE LENGTHS INPUT FOR REAL MESSAGES WITH AVERAGE MESSAGE LENGTH-STANDARD DEVIATION
ANY OUT OF RANGE?
YES
COMPUTE AVERAGE MESSAGE LENGTH USING CURRENT HOUR MESSAGE QUEUE
NO
TABULATE NUMBER OF MESSAGES OF EACH TYPE AND NUMBER OF MESSAGES OF EACH PRIORITY
DISPLAY ON CRT: (SEE FIGURE 3-11)
AVERAGE MESSAGE LENGTH THIS HOUR___
SIMULATION GENERATED AVERAGE LENGTH___
SIMULATION GENERATED STANDARD DEVIATION___
DEPRESS SEND TO CONTINUE
COMPARE WITH CUMULATIVE FREQUENCY FOR MESSAGE TYPE AND PROBABILITY
OUT OF RANGE ?
YES
DISPLAY WARNING MESSAGE ON CRT: (SEE FIGURE 3-12)
DEPRESS SEND TO CONTINUE
NO
GO TO PAGE C-7

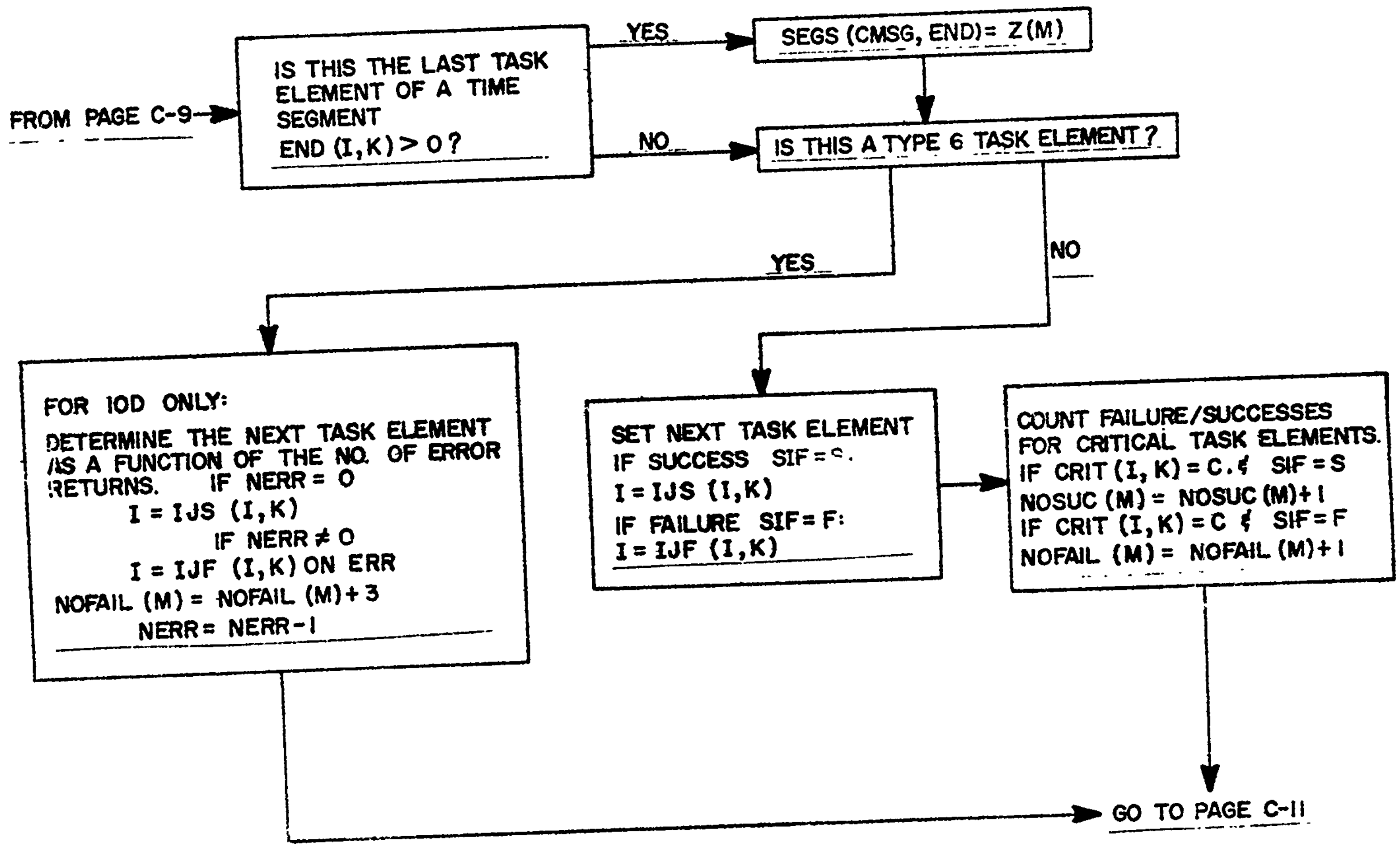


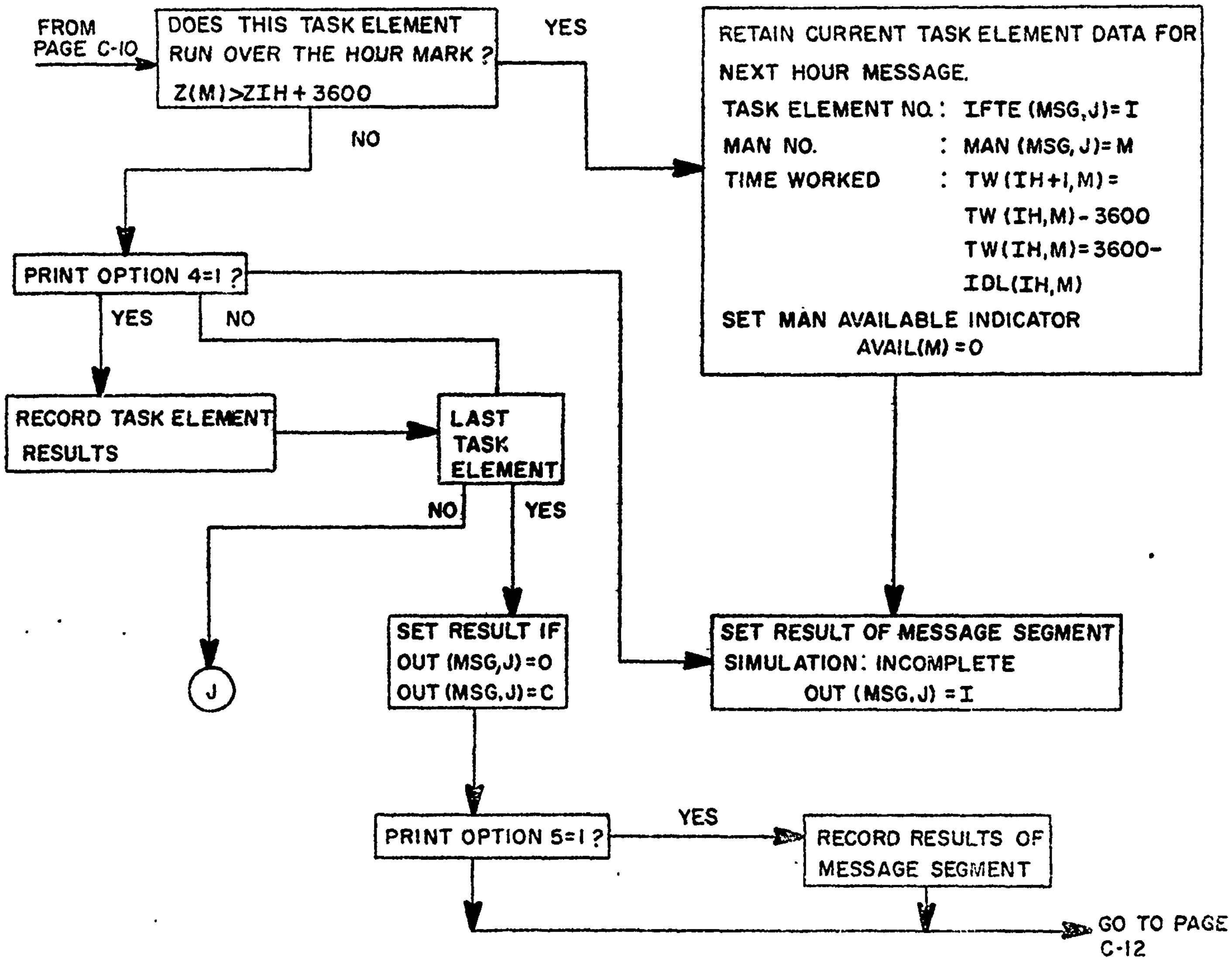
ENTER MAN DETERMINATION SUBROUTINE (MANDET)
D
FROM PAGE C-6
DETERMINE WHICH MAN TO SIMULATE NEXT.
SET OPERATOR TYPE.
TALLY IDLE TIME WAITING FOR MESSAGES.
SELECT NEXT MESSAGE TO PROCESS.
MORE TIME LEFT
G
SET PROCESSING START TIME
ST = TARIV (MSG,J)
ALL MEN FINISHED THIS HOUR
F
CALCULATE STRESS CONDITION AT START OF OPERATOR PROCESSING
AS A FUNCTION OF MESSAGE BACKLOG.
STR(M) = [NO. OF MSGS. IN APPROPRIATE QUEUE WITH (TARIV)(MSG,I)≤Z(M)] [ISTKNT(IP)] / MEN (J)
LIMIT STR (M)≥1
CALCULATE STRESS FACTOR
SF = STR(M)-1 / STRM (M)-1
J
IS MESSAGE TO BE PROCESSED BY SUBJECT ?
FMTSP (MSG,I) ≠ AND MANP (M)=1
YES
NO
DISPLAY TO CRT: (SEE FIGURE 3-14)
MESSAGE NUMBER (MSG) IS TO BE
PERFORMED BY MAN (name),
NUMBER (M) DO YOU WANT THE
SUBJECT TO PERFORM.......
M
GO TO PAGE C-8

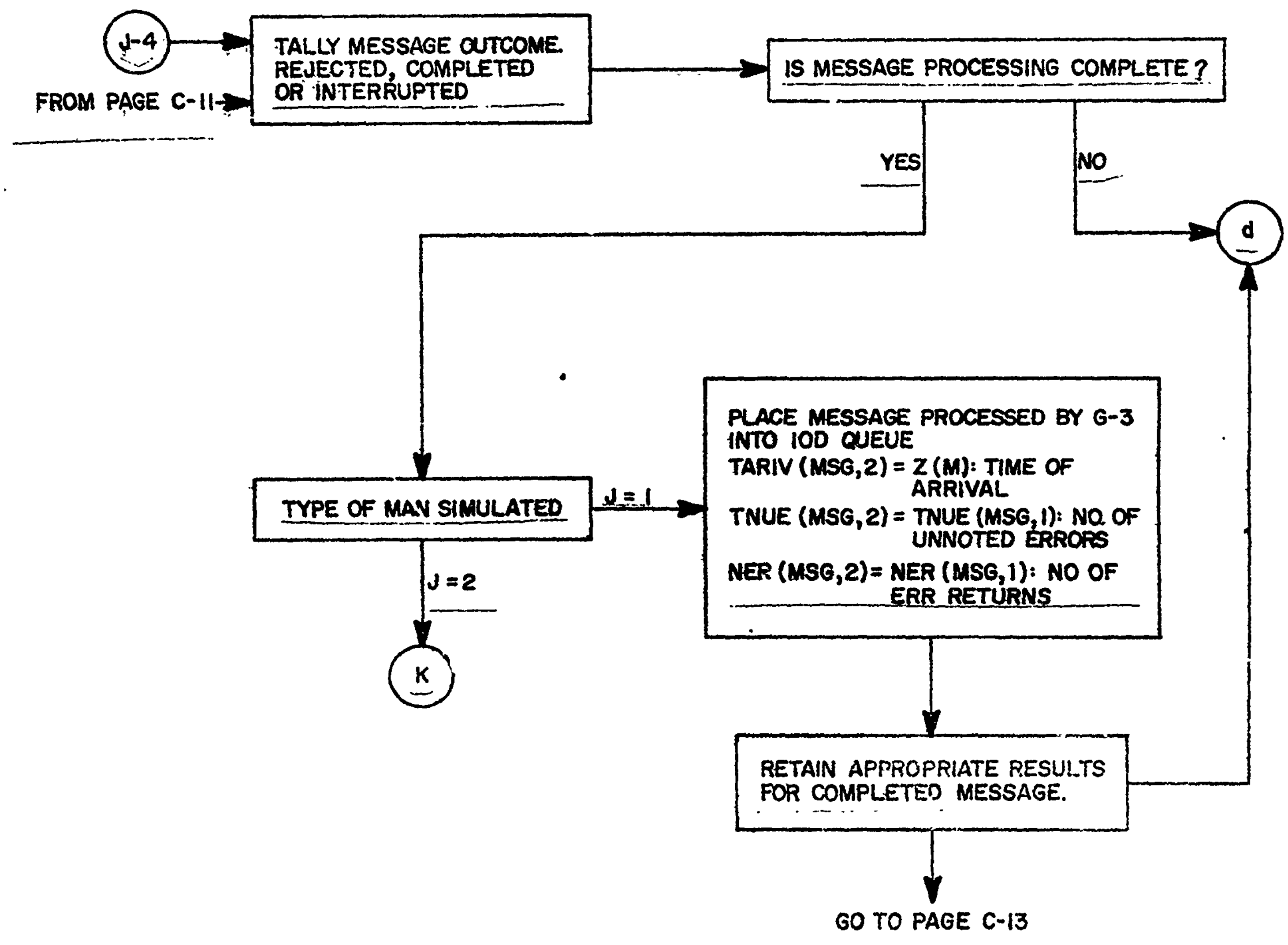

FROM PAGE C-7
DOES STRESS EXCEED STRESS THRESHOLD ? STR (M) ≥ STRM(M) ?
YES
NO
IS MESSAGE OF LOW PRIORITY ? PRIOR(MSG,J)=1 ?
NO
H
REMOVE MESSAGE FROM QUEUE
MESSAGE RECORDS ? PRINT OPTION 5 ?
1
OTHER
D
RECORD RESULTS FOR ONE OPERATOR PROCESSING OF ONE MESSAGE.
D
'NO' RESPONSE
M
EXPERIMENTER ENTERS 'YES' OR 'NO'
'YES' RESPONSE
J-0
H
PROCESS TASK ELEMENT AS IN OPERATOR PROCESSING SUBROUTINE
PRINT OPTION 4
IS TASK ELEMENT TO BE PERFORMED ? TASKPS(K,I)=P ?
NO
YES
J-2
LAST TASK ELEMENT ?
NO
I=I+1
GO TO PAGE C-9



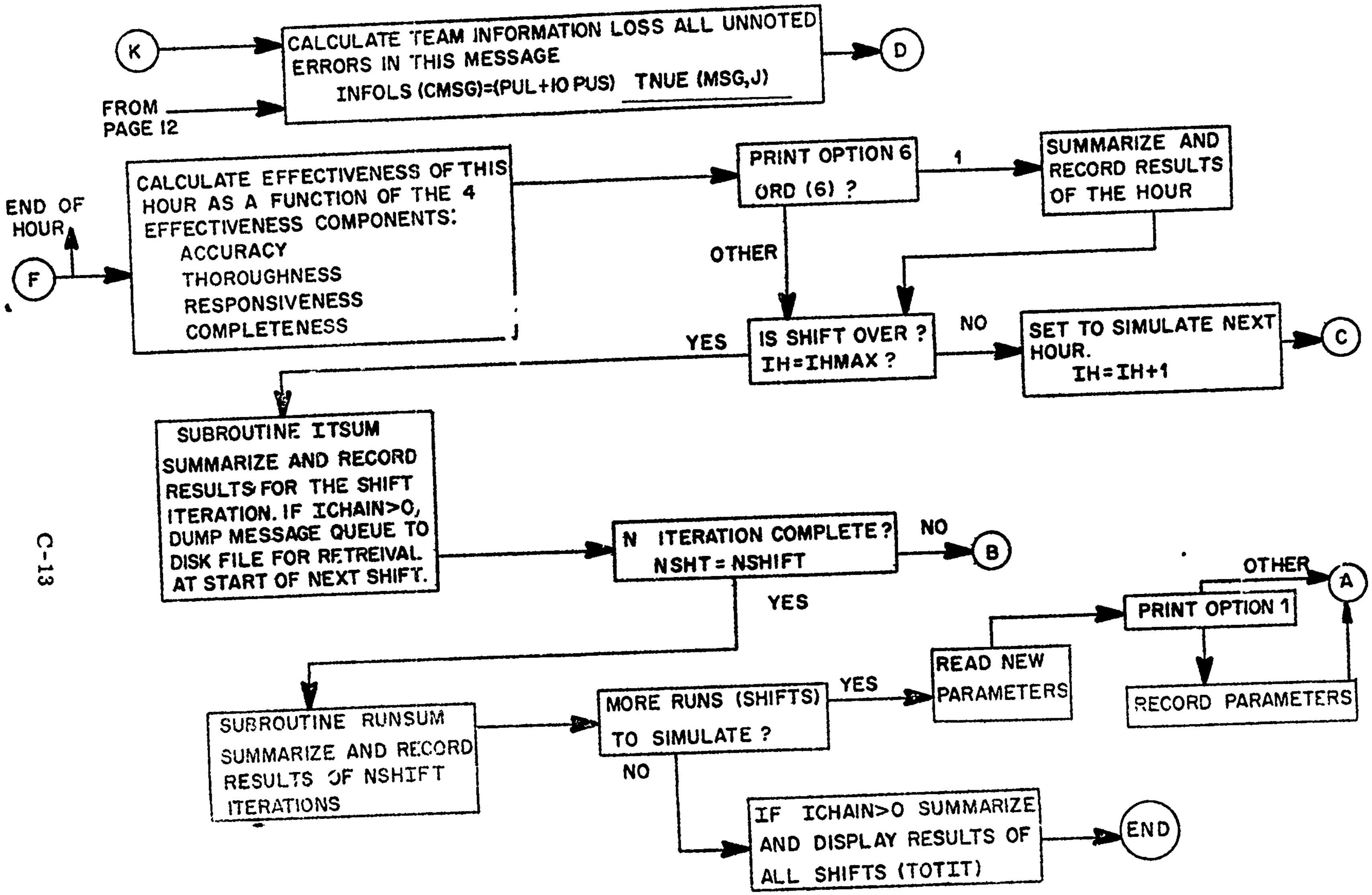
J-2
FROM PAGE C-8
DISPLAY TO CRT: IS SUBJECT TO ENTER MESSAGE ON CRT.......... (SEE FIGURE 3-(5)
EXPERIMETER ENTERS 'YES' OR 'NO'
'NO' RESPONSE
J-5
'YES' RESPONSE
SELECT TOS FORMAT FROM DISC USING FMTSP(MSG,1)
START CLOCK TO TIME SUBJECTS
DISPLAY TOS FORMAT TO SUBJECTS
SUBJECT ENTERS MESSAGE TO CRT AND DEPRESSES 'SEND'
STOP CLOCK AND COMPUTE-TIME
SELECT PROPER MESSAGE FROM DISC USING FMTSP (MSG,2)
COMPARE EACH RESPONSE FROM SUBJECT WITH CORRECT MESSAGE
SET NUMBER OF UNNOTED ERRORS FOR TASKS ELEMENT TO NUMBER OF INCORRECT RESPONSES
TNUE(MSG,J)=NO. ERRORS
SET NERR=NO. ERRORS
IF TIME >5 MINS. SET SIF=F FOR FAILURE; OTHERWISE SET SIF=S FOR SUCCESS
J-3
ADJUST TIME OF CURRENT WORK AND TOTAL WORKED
Z(M)=Z(M)+TIME
TW(IH,M)=TW(IH, M+TIME)
GO TO PAGE C-10

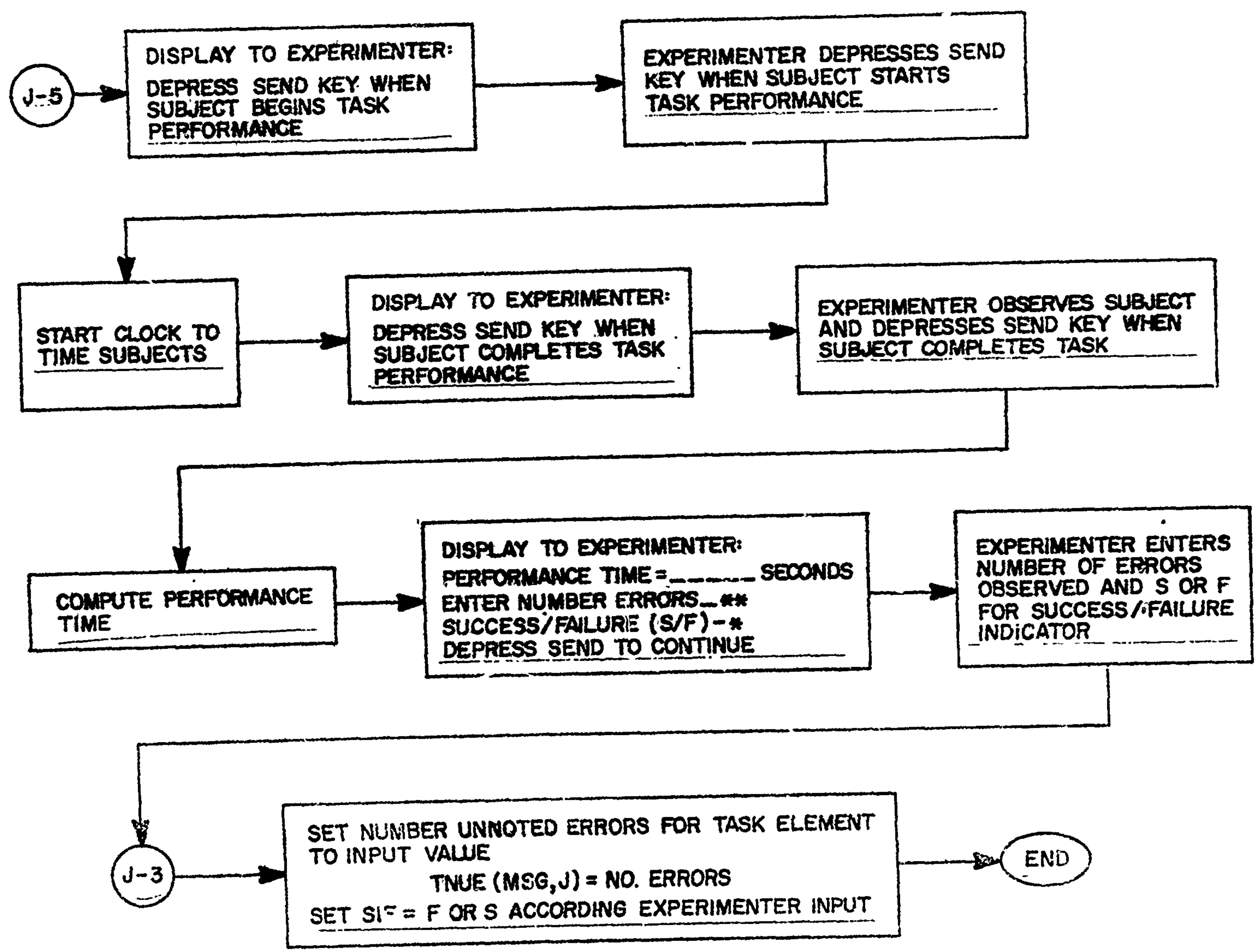

FROM PAGE C-9
IS THIS THE LAST TASK ELEMENT OF A TIME SEGMENT END (I,K) > 0 ?
YES
NO
SEGS (CMSG, END) = Z(M)
IS THIS A TYPE 6 TASK ELEMENT ?
YES
NO
FOR IOD ONLY:
DETERMINE THE NEXT TASK ELEMENT AS A FUNCTION OF THE NO. OF ERROR RETURNS. IF NERR = 0
I = IJS (I,K)
IF NERR ≠ 0
I = IJF (I,K) ON ERR
NOFAIL (M) = NOFAIL (M) + 3
NERR = NERR - 1
SET NEXT TASK ELEMENT
IF SUCCESS SIF = S.
I = IJS (I,K)
IF FAILURE SIF = F:
I = IJF (I,K)
COUNT FAILURE/SUCCESSES FOR CRITICAL TASK ELEMENTS.
IF CRIT (I,K) = C. & SIF = S
NOSUC (M) = NOSUC (M) + 1
IF CRIT (I,K) = C & SIF = F
NOFAIL (M) = NOFAIL (M) + 1
GO TO PAGE C-11


FROM PAGE C-10
DOES THIS TASK ELEMENT RUN OVER THE HOUR MARK ?
Z(M)>ZIH + 3600
YES
NO
RETAIN CURRENT TASK ELEMENT DATA FOR NEXT HOUR MESSAGE.
TASK ELEMENT NO. : IFTE (MSG,J)= I
MAN NO. : MAN (MSG, J)= M
TIME WORKED : TW (IH+1, M) =
TW (IH,M) - 3600
TW(IH,M)=3600-
IDL(IH,M)
SET MAN AVAILABLE INDICATOR
AVAIL(M) = O
PRINT OPTION 4=1 ?
YES
NO
RECORD TASK ELEMENT RESULTS
LAST TASK ELEMENT
NO
YES
J
SET RESULT IF
OUT (MSG,J) = O
OUT (MSG,J) = C
SET RESULT OF MESSAGE SEGMENT
SIMULATION: INCOMPLETE
OUT (MSG,J) = I
PRINT OPTION 5=1 ?
YES
RECORD RESULTS OF MESSAGE SEGMENT
GO TO PAGE C-12



J-4
FROM PAGE C-11
TALLY MESSAGE OUTCOME. REJECTED, COMPLETED OR INTERRUPTED
IS MESSAGE PROCESSING COMPLETE ?
YES
NO
d
TYPE OF MAN SIMULATED
J = 1
J = 2
K
PLACE MESSAGE PROCESSED BY G-3 INTO IOD QUEUE
TARIV (MSG,2) = Z (M): TIME OF ARRIVAL
TNUE (MSG,2) = TNUE (MSG,1): NO. OF UNNOTED ERRORS
NER (MSG,2)= NER (MSG,1): NO OF ERR RETURNS
RETAIN APPROPRIATE RESULTS FOR COMPLETED MESSAGE.
GO TO PAGE C-13


K
CALCULATE TEAM INFORMATION LOSS ALL UNNOTED ERRORS IN THIS MESSAGE
INFOLS (CMSG)=(PUL+10 PUS) TNUE (MSG,J)
D
FROM PAGE 12
END OF HOUR
F
CALCULATE EFFECTIVENESS OF THIS HOUR AS A FUNCTION OF THE 4 EFFECTIVENESS COMPONENTS:
ACCURACY
THOROUGHNESS
RESPONSIVENESS
COMPLETENESS
PRINT OPTION 6
ORD (6) ?
1
SUMMARIZE AND RECORD RESULTS OF THE HOUR
OTHER
IS SHIFT OVER ?
IH=IHMAX ?
YES
NO
SET TO SIMULATE NEXT HOUR.
IH=IH+1
C
SUBROUTINE ITSUM
SUMMARIZE AND RECORD RESULTS FOR THE SHIFT ITERATION. IF ICHAIN>0, DUMP MESSAGE QUEUE TO DISK FILE FOR RETREIVAL AT START OF NEXT SHIFT.
N ITERATION COMPLETE?
NSHT = NSHIFT
NO
B
YES
SUBROUTINE RUNSUM
SUMMARIZE AND RECORD RESULTS OF NSHIFT ITERATIONS
MORE RUNS (SHIFTS)
TO SIMULATE ?
YES
NO
READ NEW PARAMETERS
PRINT OPTION 1
OTHER
A
RECORD PARAMETERS
IF ICHAIN>0 SUMMARIZE AND DISPLAY RESULTS OF ALL SHIFTS (TOTIT)
END


J-5
DISPLAY TO EXPERIMENTER:
DEPRESS SEND KEY WHEN SUBJECT BEGINS TASK PERFORMANCE
EXPERIMENTER DEPRESSES SEND KEY WHEN SUBJECT STARTS TASK PERFORMANCE
START CLOCK TO TIME SUBJECTS
DISPLAY TO EXPERIMENTER:
DEPRESS SEND KEY WHEN SUBJECT COMPLETES TASK PERFORMANCE
EXPERIMENTER OBSERVES SUBJECT AND DEPRESSES SEND KEY WHEN SUBJECT COMPLETES TASK
COMPUTE PERFORMANCE TIME
DISPLAY TO EXPERIMENTER:
PERFORMANCE TIME =______ SECONDS
ENTER NUMBER ERRORS__**
SUCCESS/FAILURE (S/F) - *
DEPRESS SEND TO CONTINUE
EXPERIMENTER ENTERS NUMBER OF ERRORS OBSERVED AND S OR F FOR SUCCESS/FAILURE INDICATOR
J-3
SET NUMBER UNNOTED ERRORS FOR TASK ELEMENT TO INPUT VALUE
TNUE (MSG,J) = NO. ERRORS
SET SI = F OR S ACCORDING EXPERIMENTER INPUT
END